TUMORS OF BONE

A ROENTGENOGRAPHIC ATLAS

ANNALS OF ROENTGENOLOGY

VOLUME TWENTY-ONE

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PAUL B HOEBER, Inc *Publishers*
MEDICAL BOOK DEPARTMENT OF HARPER & BROTHERS
FORTY NINE EAST THIRTY THIRD STREET, NEW YORK 16, N Y

ANNALS OF ROENTGENOLOGY VOLUME XXI

TUMORS OF BONE

A ROENTGENOGRAPHIC ATLAS

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NEW YORK

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F-C

Library of Congress catalog card number 52-11183

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Introduction

The assistance afforded by an accurate interpretation of roentgenograms in arriving at a correct diagnosis of bone lesions can scarcely be overemphasized Despite the paramount importance of the microscopic examination in most varieties of malignant tumors the authors believe that clinical and roentgenographic studies also are essential features of the diagnostic work up of a case of suspected bone neoplasm There may be situations in which subsequent events will prove that the roentgenographic interpretation is more accurate than that of the pathologic. At least it is felt that where the x ray film and the clinical setting suggest a malignant tumor and a study of microscopic sections does not corroborate this impression one must be extremely hesitant about accepting the pathologist s report as the final word. This has been found to be especially true where the tumor is of the cartilaginous type and the microscopic diagnosis is chondroma while the films reveal areas suggestive of sarcomatous degeneration and the patient s symptoms indicate that the lesion is malignant In such cases the biopsy material may have been obtained from the chondromatous area of a tumor which also presented areas of chondrosarcoma In these circumstances the authors have learned to rely more upon the x ray film than upon the microscopic section.

A consideration of some of the fibrocystic lesions and some of those in which giant cells are prominent leads one to the conclusion that here the roentgenographic rather than the microscopic interpretation may be of greater accuracy For example the simple bone cyst and benign giant cell tumor may be confused in the histologic examination and the same may be true of nonosteogenic fibroma and fibrous dysplasia Fur

thermore the early stages of myositis ossificans may be mistaken for osteogenic sarcoma by the pathologist an error that can usually be avoided by the roentgenologist.

There are a number of non neoplastic conditions which may offer diagnostic difficulties For this reason it was felt that a collection of reproductions of roentgenograms of representative cases of benign and malignant neoplasms and associated skeletal lesions might be of value to the roentgenologist as well as to the oncologist and the orthopedic surgeon

All cases chosen have been confirmed by microscopic examination with the exception of a few as indicated in the captions Wherever possible various forms of the individual disease have been illustrated Descriptive captions accompany each illustration and in some instances microphotographs together with photographs of the patient and of the gross specimen have been added It has seemed desirable to have the illustrations of x ray films appear consistently as "negatives" in order to facilitate comparison with actual films Unless otherwise stated films shown were made prior to biopsy or treatment.

The authors are grateful to Dr Frederick S Wetherell for the time and effort he has generously given assisting us in reviewing many hundreds of films and in aiding us in the final selection In addition sincere thanks are expressed to the following Dr Clarence Halter of the Photographic Department of Memorial Hospital New York, N Y for the actual reproduction of the entire material and for obtaining the most faithful definition of every film chosen to Miss Florence Best and Miss Bertha Cairns for their secretarial assistance and finally to Mr Paul B Hoeber publisher for his cooperation in the project

1

Osteogenic Sarcoma

OSTEOGENIC sarcoma that involves a long bone most frequently arises in the metaphyseal region only rarely is the diaphyseal or epiphyseal region implicated. The long bones most often affected are the femur (distal) the tibia (proximal) and the humerus (proximal) Any of the flat bones may be involved although this is of less frequent occurrence Osteogenic sarcoma may be predominantly osteolytic, chiefly osteoblastic, or a combination of both The new bone formation may be laid down either at right angles to the long axis of the bone (sun ray appearance) or parallel to it or in a totally irregular pattern Not infrequently a triangular area of reactive new bone is laid down at the advancing margin of the tumor This formation *first described by Ernest A Codman is frequently referred to as Codman s triangle* This reactive zone may also be seen in chondrosarcoma and occasionally in Ewing s sarcoma however its presence is strong presumptive evidence of the presence of a primary bone sarcoma.

Destructive (lytic) osteogenic sarcoma may be simulated by Ewing s sarcoma and reticulum cell sarcoma occasionally by metastatic cancer and when it occurs in the epiphyseal region by aggressive giant cell tumor

Productive (osteoblastic) osteogenic sarcoma may be mistaken for sclerosing osteitis osteoid osteoma myositis ossificans and rarely for metastatic prostatic carcinoma or Hodgkin s disease There are numerous other conditions which may occasionally simulate osteogenic sarcoma rather closely but most of these are extremely rare

Osteogenic sarcoma may develop as a complication of a number of conditions which are not actually new growths of bone Among these may be mentioned

osteitis deformans fibrous dysplasia Gaucher s disease myositis ossificans and osteopetrosis Osteogenic sarcoma has been described as arising on bone that has been subjected to irradiation for some benign process (radiation osteogenic sarcoma) Of the forementioned conditions with the exception of osteitis deformans none is seen frequently as a basis for a sarcomatous degeneration Paget s disease however may be associated with sarcoma in from 5 to 10 per cent of all cases.

The roentgenographic findings are suggestive in that they usually present features of the underlying disease process in addition to secondary changes which point to a malignant lesion These changes may be gross destructive areas with or without irregular formation of new bone These features may resemble metastatic cancer rather than osteogenic sarcoma and it should be remembered that Paget s disease with superimposed metastatic renal cancer for example may closely resemble sarcoma arising on the basis of Paget s disease

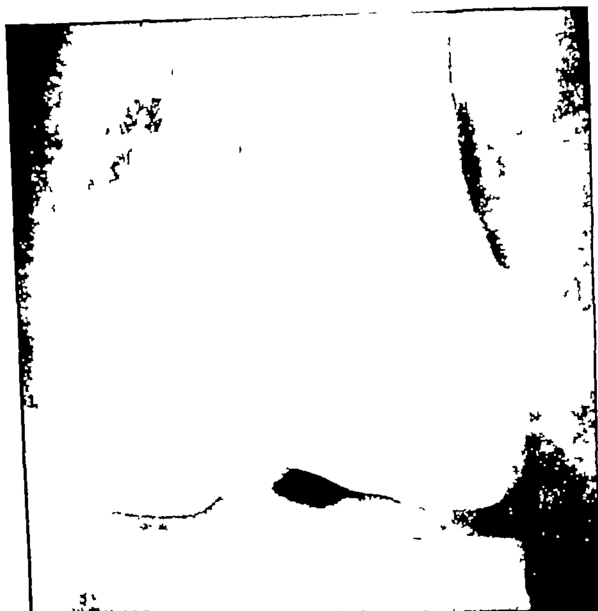


FIG 1 *Osteogenic sarcoma medullary spindle cell type* A relatively early lesion confined to the medial condyle. The normal trabecular pattern is absent and both bone productive and destructive phases are seen At this stage there has been little alteration in the general outline of the medial condyle Although the presence of this tumor was discovered and its true nature recognized promptly amputation was followed by pulmonary metastasis.





FIG 2 *A and B* *Osteogenic sarcoma large spindle cell and giant cell type a striking example of the sclerosing variety* Note the extreme density of the proximal portion of the humerus which is sharply delimited by the epiphyseal line but on both medial and lateral aspects there is evidence that there has been formation of new bone extending beyond the normal outline of the cortex.

It has been stated that the prognosis in sclerosing forms of osteogenic sarcoma is somewhat better than that which is seen in the more destructive varieties. This is open to question Amputation failed in this case owing to subsequent pulmonary metastasis.



FIG 3 *A and B* *Osteogenic sarcoma spindle and giant cell type in an 11 year old boy* The lesion is characterized by both cortical and medullary destruction with accompanying sclerosing tumor bone formation. The epiphyseal barrier has not been transgressed, but while the location of the tumor is primarily metaphyseal it has extended proximally into the diaphysis.

The subsequent course in this case illustrates how unpredictable the outcome is in this disease The age of the patient, the type and extent of the tumor and its roentgenographic appearance all tend toward an early unfavorable result. This patient, however is alive and well four and one-half years after amputation.





Fig. 2 *A and B* *Osteogenic sarcoma large spindle cell and giant cell type a striking example of the sclerosing variety* Note the extreme density of the proximal portion of the humerus which is sharply delimited by the epiphyseal line, but on both medial and lateral aspects there is evidence that there has been formation of new bone extending beyond the normal outline of the cortex.

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FIG. 5 *A and B Osteogenic sarcoma spindle and giant cell type in an 11 year old boy* The lesion is characterized by both cortical and medullary destruction with accompanying sclerosing tumor bone formation. The epiphyseal barrier has not been transgressed, but while the location of the tumor is primarily metaphyseal, it has extended proximally into the diaphysis.

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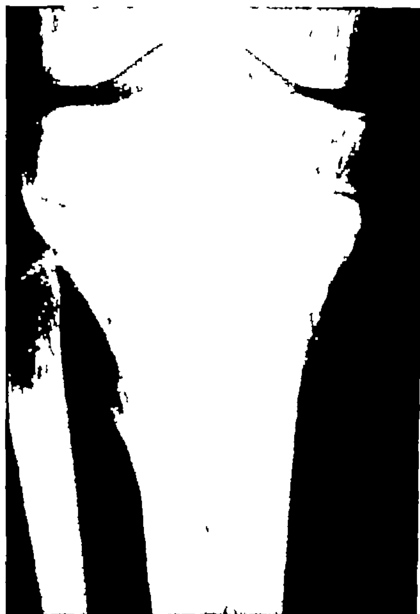


FIG 4 *Osteogenic sarcoma* The process is sharply delineated proximally by the epiphyseal line It is associated with a marked but patchy tendency to *sclerosis* and would properly be termed *sclerosing osteogenic sarcoma* The sclerotic bone is patchy and irregular in its distribution At one point on the medial aspect the cortex is broken and an area of density is visible which extends into the soft tissues. On the lateral aspect inferiorly there is a well developed zone of reactive bone at the margin of the tumor which is typical of the Codman's triangle

The patient was an adolescent girl Death from pulmonary metastasis occurred.



Fig 5. *Osteogenic sarcoma.* There is a soft, blurred outline to the productive new bone formation which is present on the medial, and to a lesser degree on the lateral margin of the cortex of the fibula Between these areas the entire thickness of the bone is altered by dense sclerotic tumor involving the metaphysis. Distal to the sclerotic area irregular bone destruction may be seen This film presents a typical appearance of osteogenic sarcoma Death from metastasis occurred following amputation



FIG 6 *Osteogenic sarcoma (fibromyxosarcoma)* A medullary osteolytic and non bone forming variety of this disease occurring in a 60-year-old man By roentgenogram alone metastatic cancer plasma cell myeloma and even fibrous dysplasia would have to be considered

This case might be expected to have had a more favorable prognosis owing to the age of the patient and the fact that the lesion was medullary in origin and confined by an intact cortex Despite these features hip disarticulation was not successful as lung metastasis supervened



FIG 7 *Osteogenic sarcoma* This represents an osteolytic and highly anaplastic form The shaft is slightly expanded and the cortex is broken on the medial aspect. The epiphyseal line sharply delimits the upward extension of the disease The features presented here are somewhat uncommon in osteogenic sarcoma but they are suggestive of a malignant and not a benign process. The clinical course was in keeping with the highly malignant histologic appearance of the tumor Amputation was followed by pulmonary metastasis.



FIG 8 *Medullary spindle cell fibrosarcoma of bone* Note the expansion of the head of the fibula, the cortical as well as medullary destruction with loss of all normal trabecular pattern This lesion closely resembles malignant giant cell tumor and might also be mistaken for medullary chondrosarcoma Actually it had been treated previously elsewhere with X ray for more than one year on the roentgenographic diagnosis (without biopsy support) of giant cell tumor This case illustrates the hazards of treatment of bone tumors by either radical surgery or roentgen therapy prior to obtaining microscopic diagnosis. This patient was a 28-year-old man and was known to be alive and well eight years after amputation above the knee.



FIG 9. *Osteogenic sarcoma* This is a medullary osteolytic variety which is difficult to distinguish from metastatic carcinoma plasma cell myeloma and certain fibrocystic lesions of bone Such cases emphasize the need for microscopic confirmation of suspicious lesions. The patient was an adult male within the age range of myeloma or metastatic cancer The appearance of this lesion suggests that aspiration might readily be done and the microscopic diagnosis thus obtained.

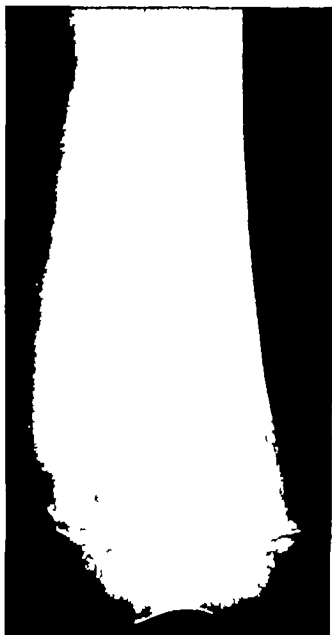


FIG 10 *Osteogenic sarcoma telangiectatic type occurring in a 6-year-old girl* There is a typical Codman's triangle The bone destruction is limited distally by the epiphyseal line Bone production is minimal This is a classical roentgenogram of osteogenic sarcoma. Microscopically the growth was of the highly anaplastic telangiectatic type Although the age is exceedingly unfavorable the patient is alive and well sixteen years after amputation, preceded by high voltage X-ray treatment. Such an outcome is most unusual at this age and in this type of osteogenic sarcoma.



Fig 11 *A and B* *Osteogenic sarcoma* The cortex is destroyed the medullary portion of the head and neck is filled with mottled areas of calcification and sclerosing osteoid tissue. The lateral border presents an advancing tumor which extends into the soft parts. Death occurred nine weeks after the onset of symptoms despite prompt amputation There is nothing specific about the appearance of this roentgenogram that would indicate such a fulminant course The patient was an adult female



FIG. 12 *A and B Osteogenic sarcoma of an unusual appearance* The tumor is purely osteolytic with destruction of the cortex and spongiosa. The patient was a young adult. In an older person metastatic cancer would have to be seriously considered. Metastasis took place to other bones but none was detected in the lungs. This case was selected to illustrate what a wide variety of X ray features may be produced by tumors which all fall into the histologic category of osteogenic sarcoma.





FIG. 13 *A and B* *Osteogenic sarcoma* Note the metaphyseal location the presence of reactive bone at the upper margin of the area of involvement (Codman's triangle) and the presence of bone destruction together with new bone formation laid down irregularly There is marked increased density in the metaphyseal portion of the bone. Anteriorly there is a long, slender spicule of reactive bone An epiphyseal pathologic fracture has occurred with unusual extension of the tumor into the epiphysis as shown in the gross specimen Such violation of the epiphyseal cartilage plate is most unusual, except in far advanced cases.



FIG 14 *Extensive osteogenic sarcoma of femur* The distal third of the bone is diffusely affected with marked tendency to sclerosis of both condyles. Irregular new bone production is seen on both medial and lateral aspects Codman's triangle is present. Following amputation a separate osteogenic sarcoma of the proximal end of the humerus developed which was sclerosing in type It is exceedingly rare to find cases which after many months develop a second osteogenic sarcoma in another long bone, especially when the chest film remains negative for metastasis following amputation In these cases one must speculate as to whether the second tumor is another primary sarcoma or a metastasis from the first.



FIG 15. *Osteogenic sarcoma of femur* This unusual form of sclerosing osteogenic sarcoma presents some roentgenographic features of longstanding infection This tumor developed more slowly than do most osteogenic sarcomas Despite amputation pulmonary metastasis supervened thirteen months later In spite of the tumor's extent, its origin in the metaphysis is evident. The patient was a young man



FIG 16 *Osteogenic sarcoma of fibula.* The location in the diaphysis is unusual While chiefly osteolytic, there is much new tumor bone The continuity of the fibula is destroyed but the adjacent tibia seems un involved. In the distal portion of the shaft, the advancing margin of the tumor can be seen The patient was a woman in her sixth decade Amputation failed to prevent death from pulmonary metastasis.



Fig 17 *Osteogenic sarcoma presenting unusual roentgenographic features* The lesion is medullary in origin almost entirely osteolytic, with no obvious soft part swelling, and the roentgenographic features are not typical of this disease The patient was an adolescent girl From a roentgenographic standpoint Ewing's sarcoma might be considered In an older person the possibility of metastatic carcinoma would have to be seriously thought of.

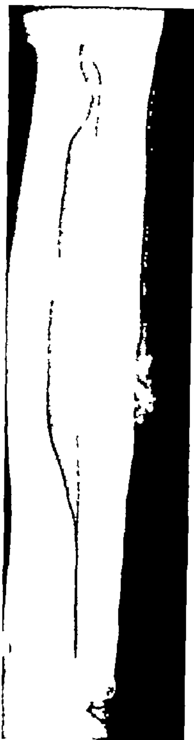


FIG 18 *Extremely low-grade periosteal spindle cell fibrosarcoma of ulna* At the time this roentgenogram was taken symptoms had existed for five years. There is a broadening of the diaphysis without much change in the bone texture. The dense, bony proliferation seen in the center of the area was shown on serial films to be increasing gradually in size. Though not shown in this view there was a fusiform soft part swelling which overlay the area of new bone formation This type of lesion lends itself to segmental resection which was practiced in this instance with an excellent five year postoperative result.

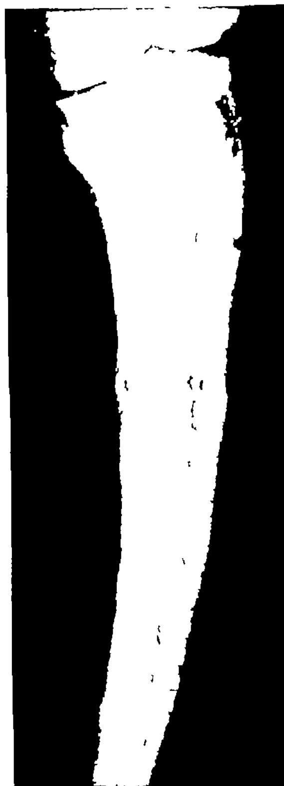


FIG 19 *Osteogenic sarcoma on Paget's disease (Paget's sarcoma)* The tibial lesion is only one of many which were typical of osteitis deformans. Persistent pain increasing in severity prompted repeated roentgenographic examinations of the tibial area. Two months after this film was made another was thought to confirm the suspicion of osteogenic sarcoma and a biopsy established the diagnosis.

This case illustrates the importance to be attached to continuing pain of a progressive character in an area of Paget's disease as indicative of sarcomatous transition If symptoms persist roentgenographic examination should not be long deferred.



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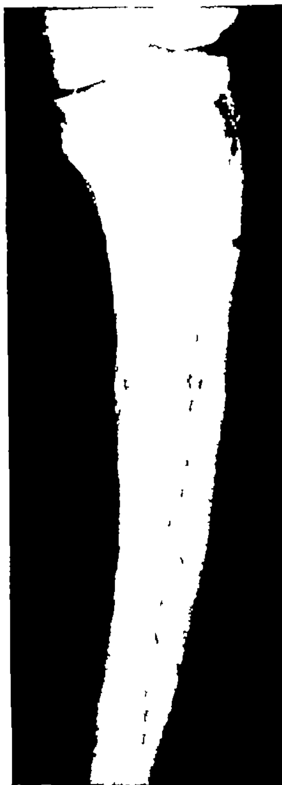


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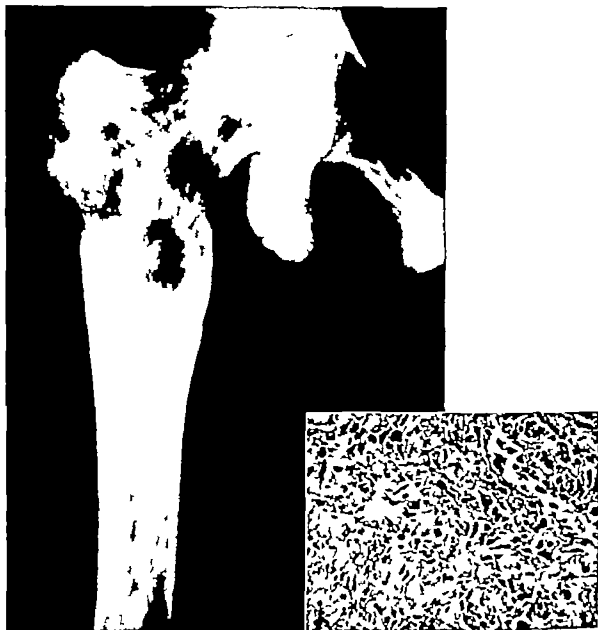


Fig 22 *A and B* *Osteogenic sarcoma arising in one area of polyostotic fibrous dysplasia.* In addition to areas of fibrous dysplasia in proximal shaft of femur and pubic ramus, there was involvement of the tibia on the same side Note the irregular bone destruction in the greater trochanter and base of the femoral neck which represents the site where osteogenic sarcoma has developed Malignant degeneration on the basis of fibrous dysplasia is quite rare

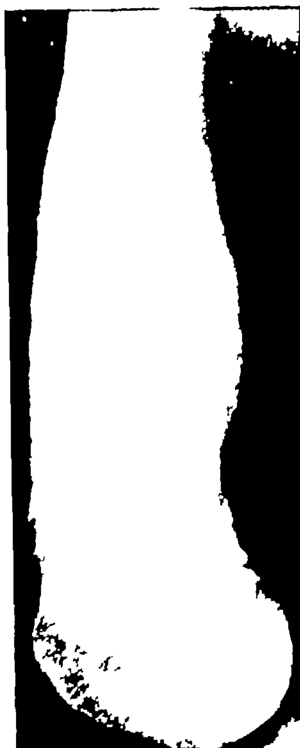


Fig. 23. *Osteoid osteoma* Note extensive sclerosis of wide area of lower end of femur The nidus is clearly seen as a radiolucent spherical zone however several exposures of different degrees of penetration were necessary to demonstrate it. This case was seen many years prior to recognition by Jaffe of this disease and was treated by roentgen therapy (*see* Fig 24)

Osteoid osteoma is uncommon but by no means rare and in recent years it is being recognized by roentgenologists with ever increasing frequency Pain is the presenting symptom in practically every case and it is characteristically controlled by aspirin in mild to moderate doses. When the nidus is removed at operation pain is promptly and completely relieved

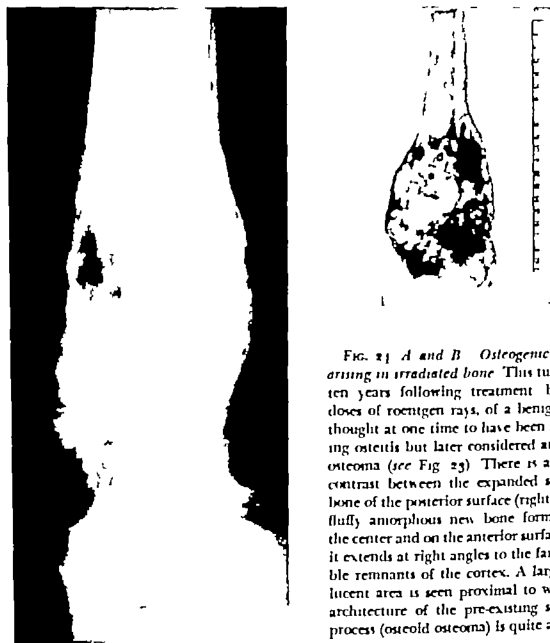


FIG. 21 *A and B* *Osteogenic sarcoma arising in irradiated bone* This tumor rose ten years following treatment by heavy doses of roentgen rays, of a benign tumor thought at one time to have been a sclerosing osteitis but later considered an osteoid osteoma (*see* Fig 23) There is a striking contrast between the expanded sclerosing bone of the posterior surface (right) and the fluffy amorphous new bone formation in the center and on the anterior surface where it extends at right angles to the faintly visible remnants of the cortex. A large radiolucent area is seen proximal to which the architecture of the pre-existing sclerosing process (osteoid osteoma) is quite apparent.



Fig. 25. *Osteogenic sarcoma of the femoral neck arising in radium dial worker.* Note that the process is chiefly lytic and lacks the distinctive features seen in most of the other forms of osteogenic sarcoma. Without a history of exposure to radioactive substances a correct diagnosis would seem impossible on roentgenographic evidence. Metastatic carcinoma would be a reasonable diagnosis from a study of this film alone.



FIG 26 *Typical extensive pulmonary metastasis from a medullary osteogenic sarcoma of humerus histologically classified as fibrosarcoma type* Note that both lungs are involved and that the deposits are roughly spherical and rather sharply circumscribed. While these features are obvious in this case the roentgenologist is often called upon to interpret films where the recognition of early pulmonary involvement is by no means a simple matter Given the fact that a sarcoma is present or has been removed it is most likely that any doubtful shadow is due to metastatic disease.



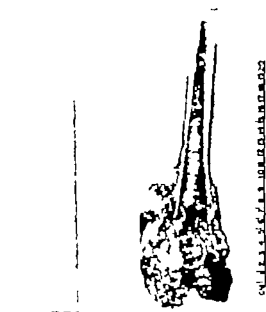


FIG 27 *A and B Pulmonary metastasis from osteogenic sarcoma* This lesion was first detected five years after amputation for a sarcoma primary in the lower femur reported by the pathologist as of relatively low-grade malignancy Because of the absence of demonstrable metastasis elsewhere in the lungs so long after amputation a resection of this metastatic area was done Microscopically the metastasis resembled the primary tumor There has been no evidence of further pulmonary metastasis during a period of more than four years, and the patient remains well nine years after amputation Such a fortunate outcome is unique in our experience

2

Chondrosarcoma

PRIMARY (chondroblastic) chondrosarcoma may present virtually the roentgenographic features as osteogenic sarcoma

Secondary chondrosarcoma (chondromyxosarcoma) usually presents definite dence of the pre-existing benign central chondroma or osteochondroma from w it is derived. If not discovered relatively early in its course the sarcomatous fea may so overshadow the original benign tumor as to make it difficult or impossib demonstrate it The roentgenographic appearance of a benign central cartilagi tumor is rather characteristic It is chiefly osteolytic although there may be ca stippling which should serve to distinguish it from other central lytic areas of b There may be no alteration in the configuration of the cortex but in some instanc may be thinned and expanded Actual evidence of bone destruction in a medu chondroma should make one suspicious of a chondrosarcomatous change that already taken place If films of an osteochondroma reveal abnormal areas of b destruction or areas of soft part density in which there are calcific deposits e finely or coarsely stippled these findings likewise point to a chondrosarcoma alteration

Particularly in chondromatous tumors of the pelvic bones the slow progre increase in size may be demonstrated over a period of three to five or more y Such tumors are insidious since secondary chondrosarcoma is extremely pron develop and it may not be possible to note the inception of such malignant tr formation merely by a study of the roentgenograms When serial films, however close a progressive increase in size or destruction the seriousness of the potential is certain. This statement also holds true for large cartilaginous tumors in other bo

Chondrosarcoma (primary chondroblastic sarcoma) may frequently appear on roentgenograms as indistinguishable from osteogenic sarcoma. Some pathologists prefer to include chondrosarcoma as a variety of osteogenic sarcoma and offer rather convincing arguments on the propriety of such classification. Since the method of treatment and the prognosis are the same, it is perhaps merely a matter of academic interest.

Secondary chondromyxosarcoma, on the other hand, we feel merits a separate classification for the following reasons: it is derived from a pre-existing central chondroma or peripheral osteochondroma, has a more insidious onset, and has a much more favorable prognosis than has osteogenic sarcoma or chondroblastic sarcoma.



FIG 28 (Continued) *Early primary chondrosarcoma of the femur in young adult male* The location in the metaphysis is typical The cortical line is broken and the process is characterized by bone destruction as well as by soft fluffy mottled productive growth which extends into the soft parts The gross specimen shows the extent of the lesion its tendency to elevate the periosteum and yet to be confined by it The microphotograph shows a dense mosaic of atypical bone trabeculae within whose interstices are tumor cells.



Fig 28





FIG 28 (*Continued*) *Early primary chondrosarcoma of the femur in young adult male* The location in the metaphysis is typical The cortical line is broken and the process is characterized by bone destruction as well as by soft fluffy mottled productive growth which extends into the soft parts. The gross specimen shows the extent of the lesion its tendency to elevate the periosteum and yet to be confined by it The microphotograph shows a dense mosaic of atypical bone trabeculae within whose interstices are tumor cells.

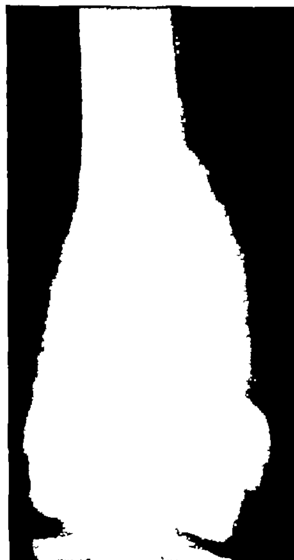


FIG 29. *Primary chondrosarcoma.* An advanced lesion with diffuse involvement of an extensive area of the femur Apparently arising in the metaphysis, the process has already extended nearly to the mid shaft. *Note the roentgenographic similarity of this disease to osteogenic sarcoma.* Indeed, the appearance is so like that of osteogenic sarcoma that it is almost impossible to make the distinction on other than histologic grounds. Note the presence of the reactive bone triangle of Codman which is being invaded from below by advancing tumor Some pathologists are inclined to include chondroblastic sarcomas such as this in the general category of osteogenic sarcoma. The prognosis in such chondrosarcomas is equally unfavorable.

The patient was an adolescent boy who succumbed to pulmonary metastasis following amputation



FIG. 30 *A and B* *Primary chondrosarcoma.* The distal ulna is a most unusual site. A reactive zone of new bone is indistinctly seen on the medial side (Codman's triangle) The ulnar styloid is completely obliterated by a dense sclerosing process. The purely destructive features are seen only proximal to the bulk of the tumor mass. From a roentgenographic standpoint osteogenic sarcoma would be a reasonable diagnosis. The clinical course prognosis and indications for treatment coincide so closely with that of osteogenic sarcoma that actually the distinction between the two types of tumor is largely an academic one.



FIG 51 *Chondrosarcoma of fibula.* There is marked alteration of the normal configuration of the proximal end of the fibula with irregular bone destruction and a conspicuous mass composed of cartilaginous tumor with marked calcification which projects laterally from the neck of the fibula. This is a relatively uncommon site for bone sarcoma. The patient was a young man.



Fig 32 *Primary chondrosarcoma* There is almost total involvement of the os calcis in a dense calcified tumor which presents an irregular edge inferiorly with fluffy extension into the soft parts of the plantar aspect of the heel From a roentgenographic standpoint this lesion might readily be termed osteogenic sarcoma. The patient was a fifteen year-old girl who has survived twenty years following amputation at site of election below the knee



FIG 35 *Chondrosarcoma of medullary type* This condition almost certainly developed on the basis of a benign central chondroma and for a time was interpreted roentgenographically as a giant cell tumor before a final pathologic diagnosis of chondrosarcoma was made While there is a definite tendency to encapsulation an area where this has been broken through is readily seen. If at the outset reliance had been placed solely on the roentgenographic interpretation this lesion might have been treated with X rays as a giant cell tumor Based on aspiration biopsy this tumor was reported as low-grade chondrosarcoma. The patient has remained well with preservation of the limb for seventeen years following curettage



FIG 36 *A and B Secondary chondrosarcoma of ilium* The entire ilium is involved. This type of tumor arises on benign chondroma and develops gradually with slow growth. This patient had been aware of the tumor for more than five years Microscopic study of the entire tumor following hemipelvectomy revealed chondroma only but the patient succumbed to pulmonary metastasis two years after operation. The radiopaque portions of the tumor are due to dense calcification and not to new bone formation This case illustrates the danger of relying on a pathologic diagnosis of benign chondroma in a large tumor which has exhibited steady insidious enlargement. In cases like this one where the pathologist reported only chondroma, the roentgenographic and clinical diagnosis should take precedence.

3

Ewing's Sarcoma of Bone (Endothelioma of Bone)

IN RECENT years, some doubt has been cast on the authenticity of endothelioma of bone by a few authorities who maintain that despite Ewing's concept of its origin from vascular endothelium in bone it has never been proved to originate in the endothelium Some writers believe that tumors which have been designated as Ewing's sarcoma are in reality examples of metastatic neuroblastoma. There are others who do not recognize any distinction between Ewing's sarcoma and primary reticulum cell sarcoma of bone

Despite these academic viewpoints we may consider that there is a specific disease of bone probably a primary sarcoma commonly accepted by most authorities as Ewing's sarcoma, but with doubt as to its derivation from endothelium of bone vessels. It is this tumor to which we refer here

At the outset we must concede that while typical forms of the disease produce roentgenographic features that are quite distinctive and that may be readily diagnosed, there are many cases in which the features of a subacute bone infection are simulated in fact this may at times be one of the most difficult differential diagnoses in the field of bone neoplasms. Other cases closely resemble osteogenic sarcoma.

The typical lesion of Ewing's sarcoma occurs in the diaphysis of a long bone and often when first seen has produced demonstrable changes in one-third to one-half of the shaft. It is osteolytic although reactive bone may be produced at the margins of

the tumor which may simulate the Codman's triangle seen in osteogenic sarcoma Ewing's sarcoma destroys the cortex in a peculiar way it tends to split it into sheets or lamellae which give rise to its onion skin or plywood appearance It generally produces considerable soft part swelling which is usually fusiform in shape rather than globular or pear shaped as is the case with osteogenic sarcoma As it grows the tumor destroys the cortex invades the medullary canal and may travel far beyond the limits of invasion as determined by roentgenograms Other conditions which are confused with Ewing's sarcoma include reticulum cell sarcoma angiosarcoma eosinophilic granuloma metastatic neuroblastoma and inflammatory lesions of bone such as lues It is worthy of mention that Ewing's sarcoma may present a wide range of variable features as seen on X ray films To substantiate this statement one has but to examine a large number of cases roentgenographically in which the pathologic diagnosis of Ewing's sarcoma has been rendered



FIG. 37 *Ewing's sarcoma an exceedingly early example in a 17 year-old girl* At this stage of the disease classical X ray changes are lacking and the only significant feature is irregular cortical destruction One could predict that the lesion is malignant but microscopic confirmation is essential It could easily be mistaken for reticulum cell sarcoma of bone. This patient survived four years and ten months after roentgen therapy At autopsy multiple bone and visceral metastases were found

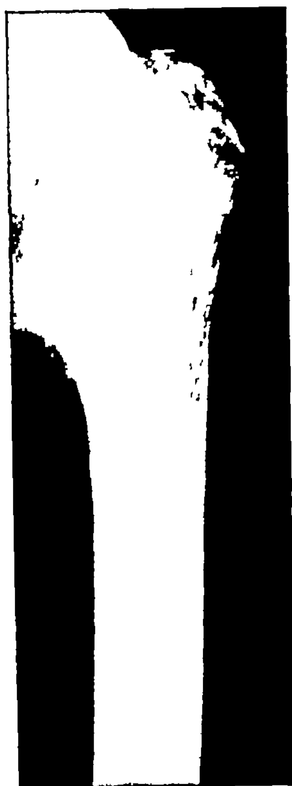


FIG. 58. *Ewing's sarcoma (endothelioma) in a 27-year-old male.* There is considerable similarity to the appearance seen in early cases of bone infection, a feature that has been repeatedly emphasized. In this instance there is neither periosteal reaction nor distortion of the normal outline of the femur and none of the reactive bone condensation which is usually seen in osteomyelitis.

It is seldom possible to determine from the roentgenogram the distal or proximal limits of the disease because at the growing margin the lesion fades off imperceptibly into normal appearing bone. The wide extent of the disease in many cases has led to the belief that in treating a primary endothelioma in any bone the portals of X-ray therapy should extend far beyond the apparent confines of the tumor as judged by X-ray films and by clinical examination. Failure to take this precaution may result in local "recurrence" adjacent to the area treated.



FIG 39 *A and B Ewing's sarcoma (endothelioma of bone) in a 20-year-old man* The diaphyseal location wide extent of involvement expansion with lamellar reactive bone and irregular cortical destruction are typical roentgenographic features. The photograph of the gross specimen reveals a pathologic fracture which occurred after the roentgenogram was made It also discloses the fact that the disease extends throughout the entire portion of the specimen



Fig. 40 *Ewing's sarcoma (endothelioma) of tibia in a 10-year-old female* This case illustrates the lack of consistency in the roentgenographic appearance of this disease Here, the process occupies an area more commonly the site of osteogenic sarcoma and the "onion skin" lamellation is absent. The lesion however is osteolytic and extends further down the shaft than is apparent on superficial examination In this case there were metastases to radius, femur and other bones.

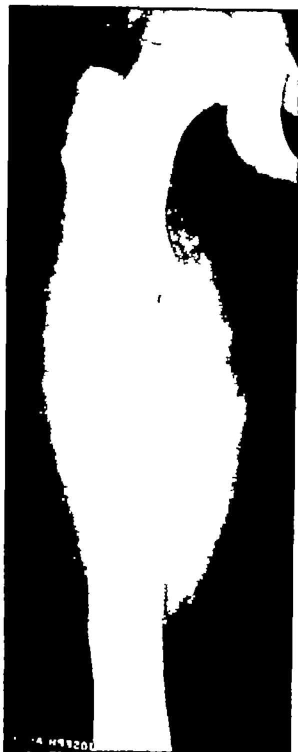


FIG. 41 *Ewing's sarcoma (endothelioma) in a 19-year-old male* Here, the fusiform, bulky soft part swelling, the location in the diaphysis, the wide extent of involvement of the shaft, all are classical roentgenographic findings in this disease. Below the greater trochanter is seen productive bone formation which is reactive rather than tumor bone yet this feature is more typical of osteogenic sarcoma since the new bone is laid down at right angles rather than parallel to the shaft. The extraordinary variation in the radiographic appearance which this tumor can produce makes it extremely difficult to make a correct diagnosis in many cases. It is our impression that the classical description fits only about half of the cases encountered Histologic confirmation is essential



FIG. 42 *Ewing's sarcoma (endothelioma) of fibula* The features here presented are the position in the diaphysis the wide extent of involvement and the irregular destruction of cortical bone with expansion of the fibular shaft The often described onion-skin lamellated appearance is lacking This is one of the most radiosensitive primary bone tumors exceeded only by reticulum cell sarcoma. As adequate X ray treatment usually will control the local lesion and as regardless of the type of therapy death almost always occurs we have discontinued routine amputation in favor of irradiation and reserve surgery for the occasional cases seen after biopsy has been complicated by infection and fungation.



FIG 43 *Ewing's sarcoma (endothelioma) of fibula* Note the location in the medial third of the shaft This roentgenogram lacks the typical features of this disease probably due to the fact that a small dose of X ray had been administered previously Films made much later were far more typical and microscopic proof of the nature of the disease was then obtained. One should never administer roentgen therapy in a case of suspected Ewing's sarcoma before microscopic confirmation of the diagnosis has been obtained even mild doses will render a histologic report unreliable and usually the pathologist will suspect an inflammatory process.





FIG. 44 *A and B Ewing's sarcoma (endothelioma) of tibia* Here despite the microscopic report of endothelioma the roentgenographic appearance is much more suggestive of reticulum cell sarcoma of bone. The age of the patient (30) is also more compatible with the latter diagnosis. It should be emphasized that on histologic grounds the distinction between these two tumors is sometimes extremely difficult In this case a preoperative diagnosis of fibrous dysplasia was seriously considered. This and preceding cases emphasize the fact that Ewing's sarcoma often gives widely divergent roentgenographic features and when this occurs, its correct interpretation on films alone may be almost impossible



15 16 17 18 19 20 21 22 23 24 25

Fig. 45 *A and B Ewing's sarcoma (endothelioma of bone) in an 8 year-old girl* Diffuse and extensive destruction of all the layers of the rib with some irregular bone production. In this case the diagnosis was confirmed histologically on the resected specimen Ewing's sarcoma of the ribs is uncommon and roentgenographic interpretation is even more difficult than in long bones.

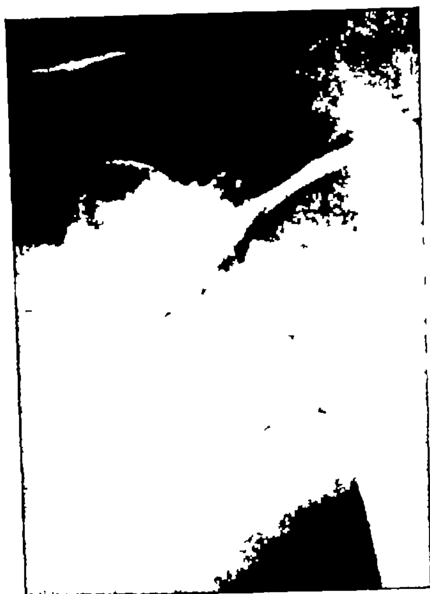


Fig. 46 *Ewing's sarcoma (endothelioma) of scapula.* The roentgenographic diagnosis of primary malignant tumors of flat bones is usually more difficult than that of long bones. The changes seen in the glenoid and beneath it are those of expansion, irregular destruction and a lamella of periosteal reactive new bone formation This is a rather early lesion

There was a globular soft part swelling which was readily seen and palpated The patient was a girl of 4 years. Death occurred from metastasis.

The tendency of this type of bone sarcoma to spread to other bones is well known. In this respect it differs from osteogenic and chondrosarcoma which spread to other bones only occasionally

4

Reticulum Cell Sarcoma of Bone

AN ACCURATE roentgenographic interpretation of reticulum cell sarcoma cannot easily be attained This has been pointed out by various authors in the past who have found the roentgenograms to be of little assistance in the diagnosis. In a recent study however Sherman and Snyder (1947)[1] have taken an opposite view maintaining that by this means a correct diagnosis can be readily reached or at least suggested

Reticulum cell sarcoma has its origin in the medullary portion of the shaft or in the subcortical cancellous portion of the extremities of long bones also in flat bones it originates beneath the cortex. As it progresses it destroys both medulla and cortex but shows little tendency to provoke periosteal reactive bone growth The destruction is manifested by a finely granular or patchy osteolytic process. There is often a slight expansion of the shaft of a long bone producing a widened and fusiform enlargement. The picture produced by these changes may be described as a cracked ice appearance. Frequently a considerable soft part mass is evident which may be demonstrated on the X ray film At times this mass becomes more conspicuous than the bone involvement and thus where the tumor lies near a joint may lead to the misconception that it is a synovioma.

The presence of a tumor which may superficially resemble Ewing's sarcoma in a patient past 25 years of age is strongly suggestive of reticulum cell sarcoma. Osteomyelitis is another lesion which may produce bone changes which closely resemble reticulum cell sarcoma. In 50 per cent of cases seen by the authors the femur or tibia was the site of involvement

[1] SHERMAN, R S and SNYDER, R E Roentgen appearance of primary reticulum cell sarcoma of bone. *Am. J Roentgenol.* 58: 29 -306 947

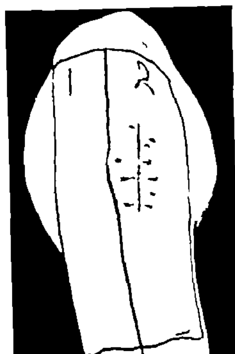




Fig 47 *A and B Reticulum cell sarcoma of proximal humerus* Note the extension of the disease from midshaft to head the irregular patchy osteolysis and the slight expansion of the shaft with some reactive bone laid down along the cortex This is a fairly typical picture of primary reticulum cell sarcoma of bone Because of the *marked responsiveness to doses of X rays* that are well within the limits which normal bone can tolerate without permanent severe damage this tumor should be treated with high voltage irradiation Moreover there is evidence which leads us to advocate the use of the mixed toxins (erysipelas and serratia marcescens Coley's toxins) By a combination of X ray and toxin treatment we have approximately 40 per cent five year survivals.

This patient is well and apparently free of disease five and one half years after treatment.





FIG 48 *A and B Reticulum cell sarcoma of ulna in a girl of 18* The lesion is an osteolytic one but the destruction is patchy and irregular leaving streaks of uninvolved bone which appear more prominent by contrast This is a fairly early lesion and following treatment with irradiation and Coley s toxins, was controlled for nine years. Local recurrence then became evident and amputation was followed by metastases and death eleven years after the diagnosis was first established microscopically



Fig 49 *Primary reticulum cell sarcoma of bone in a 25 year-old man* The disease has affected a considerable area of the distal femur and is osteolytic without any productive features The condylar portion of the bone is actually uninvolved but appears abnormally dense by contrast. Note the spotty character of the osteolytic process The patient is alive and well without symptoms and with no disability five years after treatment with X rays and toxins.

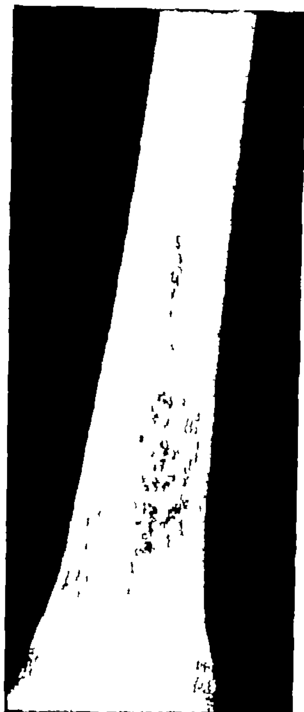


FIG 50 *Primary reticulum cell sarcoma of the femur* The shaft and metaphysis is the site of an irregularly destructive process which caused a mottled appearance more prominent in the medullary than in the cortical portion of the bone. There is no expansion and no reactive marginal bone production. This patient a middle-aged woman, is well four and one-half years following combined irradiation and toxin therapy



FIG 51 *Reticulum cell sarcoma of bone in a 54 year-old man* This is a difficult lesion to describe There is an irregular and ill-defined rarefaction with coincidental osteoblastic activity The anterior surface of the tibial cortex is not preserved while the posterior surface appears intact There is marked variation in the roentgenographic appearance of reticulum cell sarcoma Hence this neoplasm presents considerable difficulty from the standpoint of diagnosis on roentgenographic evidence alone. Amputation was performed after a dose of 1725 r of high voltage roentgen therapy· the specimen revealed no viable tumor cells despite this relatively small amount. The patient is well without evidence of disease five and three-quarter years later



Fig 52 *A and B Reticulum cell sarcoma in a 55 year-old woman* The diagnosis from roentgenographic evidence was that of osteogenic sarcoma from the biopsy specimen metastatic carcinoma of the breast, and from the entire resected specimen of the fibula, reticulum cell sarcoma. Note that in this case there was some reactive new bone formation accompanying the more prominent destructive features of the disease

Following resection patient received 1800 r depth dose of X ray therapy and has remained free of disease for three years.

5

Angiosarcoma of Bone

THIS type of tumor is rare Few roentgenologists or clinicians have the opportunity of seeing more than one or two cases. The difficulty of rendering a correct diagnosis is increased by the fact that there are no easily recognizable characteristic features to be noted on roentgenographic examination Some cases have been established as arising upon benign hemangiomas of bone Rapid growth marked pain and irregular bone destruction should in such instances arouse suspicion of angiosarcoma. The roentgenologist will have done well however to have arrived at the conclusion that the process is a malignant one and the exact diagnosis must in most cases be left to the pathologist





FIG 53 *A and B Capillary angiosarcoma in a 16-year-old girl* This is a relatively rare tumor Note the rather circumscribed area of bone destruction with dense reactive bone beneath it and a zone similar to Codman's triangle distally which might suggest osteogenic sarcoma. This tumor does not of itself produce bone but destroys it. The reactive bone marginally is normal bone stimulated by the advancing tumor

The photograph of the gross specimen shows the involvement to be sharply limited to the same area of the lateral aspect of the proximal end of the humerus which is clearly seen on the X ray film

Treatment consisted of preoperative roentgen therapy followed by interscapulothoracic amputation. Patient was well two and one half years later



Fig 51 *Liposarcoma of bone in a 49-year-old man* This is an exceedingly rare form of primary malignant bone tumor Few cases have been reported and the authenticity of the lesion as a separate entity is not generally conceded. From the roentgenographic standpoint one could consider it to be malignant and would be most likely to classify it as metastatic however a medullary osteolytic form of osteogenic sarcoma might be considered.

6

Malignant Giant Cell Tumor

WHILE the term *benign* is correctly applied to the vast majority of giant cell tumors we recognize that there is a malignant form as well The latter may occur spontaneously at the outset, or may develop during treatment upon a basically benign giant cell tumor so diagnosed by competent authorities based upon a histologic study Giant cell tumors which when first seen have had neither operation nor X ray therapy and are classified histologically as malignant are extremely rare Those, however which after curettage or roentgen therapy or a combination of both are later found to present microscopic criteria of malignancy are not so uncommon. Some authorities estimate that this malignant evolution occurs in approximately 10 per cent of cases which had been classified as benign on the first microscopic study

It is not difficult to interpret correctly the roentgenograms of an advanced case of malignant giant cell tumor but in the gradual transition of a treated case from a benign to a malignant phase it may be quite difficult. In the presence of obvious progression of the lesion and with irregular destruction of the cortex and a break through into the adjacent soft parts the correct interpretation of malignant transformation may be a relatively simple matter Borderline cases are much more of a problem The roentgenologist should be influenced by the symptom of pain its degree of severity and its increase by insensible gradations Microscopic study of aspiration biopsy material may be required for confirmation



FIG 55. *Malignant giant cell tumor in a 37 year-old woman* Before operation this unusual case was not considered seriously as a giant cell tumor or as malignant.

Malignant giant cell tumor (with no previous treatment) is exceedingly rare More over giant cell tumors of the iliac bone are also unusual. The histologic diagnosis was made at operation which consisted of curettage and implantation of bone chips of bank bone The patient is still well and active without symptoms four years later despite no further treatment. This surprising clinical result cannot readily be explained.

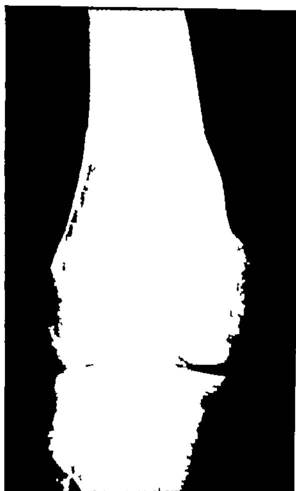


Fig. 56A

Fig. 56 *A and B* *Malignant giant cell tumor* There are two forms in which this tumor may appear the first and by far the rarer is malignant when first seen and examined histologically The second form of which this is an example, is benign at first microscopic study (Fig 56A.) but after curettage, irradiation or particularly after a combination of both it shows progressive histologic changes ending in frankly sarcomatous tissue Under such circumstances pulmonary metastasis usually supervenes.

In this 35 year-old man the sequence of events was as follows

1 Aspiration biopsy giant cell tumor"
2 Curettage "giant cell tumor (in one area giant cells are rare and in this area I would not guarantee benignancy)
3 Obvious recurrence—aspiration biopsy smear seems to indicate recurrence or extension of giant cell tumor"
4 Amputation tumor resembles the suspicious cellular area in the curettings. Is a giant cell tumor going over into a telangiectatic sarcoma?
5 Death from pulmonary and vertebral metastasis.

The microscopic examinations were reported by Dr Fred W Stewart, pathologist at Memorial Hospital New York, N Y The film from which this illustration was made shows the condition prior to amputation (*B*) and before curettage (*A*). The lateral condyle shows a "breakthrough However the roentgenographic appearance is still not inconsistent with benign giant cell tumor This case illustrates the importance of microscopic study of these tumors. The entire hospital course was only four months and the patient died eight months after his first symptom.

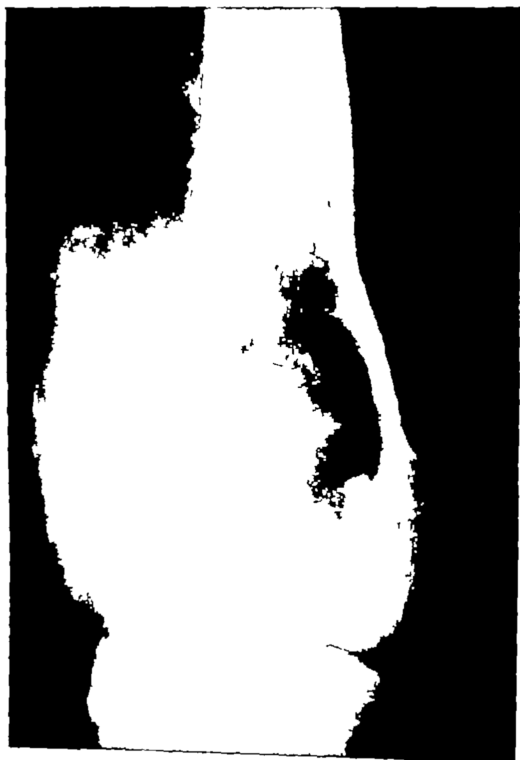


FIG 56 B

7

Plasma Cell Myeloma

SINCE three of the four forms of myeloma are considered of exceptional rarity we will confine ourselves to a discussion of the fourth i e plasma cell myeloma. This disease characteristically gives rise to multiple bone lesions which are invariably osteolytic. They may be small spherical punched-out areas or larger irregular defects. In some instances the shaft of a long bone may be expanded

Since the red marrow of the flat bones and the ends of the long bones are the site of myeloma it follows that the skull sternum vertebrae pelvis and the proximal ends of the femora and humeri are most frequently affected. At times the shafts of long bones are also involved

Solitary plasma cell myeloma has been described. Unquestionably cases are discovered which present only one focus of the disease after a complete skeletal survey In such cases however other bone lesions nearly always eventually appear and the disease progresses with a fatal outcome One cannot assume therefore that a single destructive lesion is not a myeloma

The principal problem in differential diagnosis is to distinguish between myeloma and metastatic carcinoma Both affect the same age group and the roentgenographic features may be so similar as to render a differentiation impossible In doubtful cases the elevated serum protein and reversed albumen globulin ratio may indicate myeloma A microscopic study of biopsy material will prove conclusive.

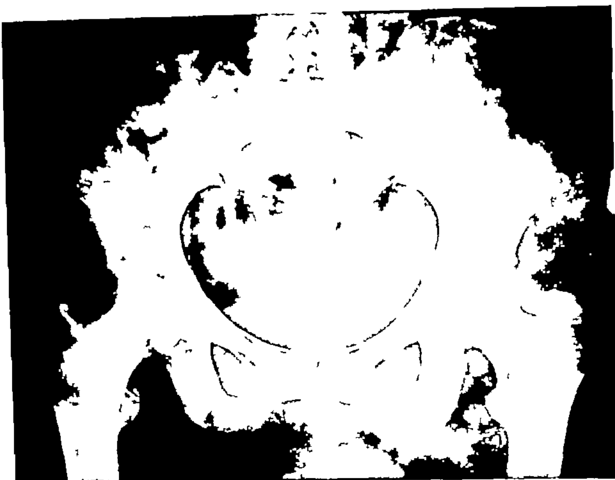


FIG 57 *Plasma cell myeloma in a 42 year-old woman* Both innominate bones and the visible portions of both femora show innumerable areas of sharply outlined lessened density many of which appear to coalesce. The only bone disease with which this condition might be confused is wide spread metastatic cancer however the complete absence of reactive marginal density is less often seen in metastatic cancer in bone. Elevation of the total serum protein and reversal of the albumen globulin ratio confirm the diagnosis



FIG. 58 *Plasma cell myeloma same case as Fig 57* Similar punched-out areas of destruction are seen in the humerus clavicle and scapula which is characteristic of this disease. The diagnosis can readily be confirmed by aspiration biopsy of any typical area or by sternal marrow puncture. Vertebral body involvement with varying degrees of collapse often give rise to back pain which may be the initial symptom

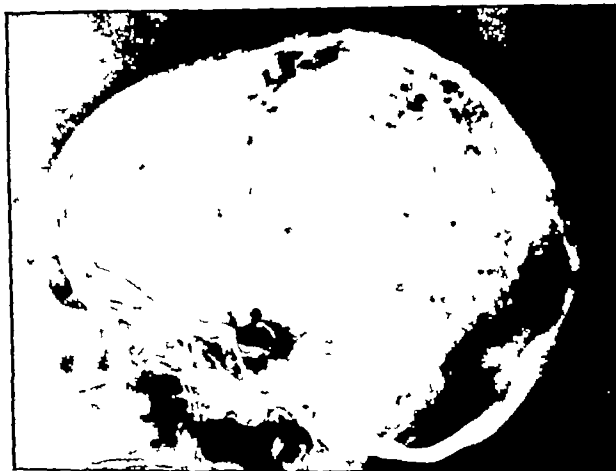


Fig 59 *Plasma cell myeloma (same case as Figs 57 and 58)* Note the multiplicity of small punched-out lesions which in the skull is seldom seen in metastatic cancer



FIG 60 *Plasma cell myeloma in a 56-year-old woman* Typical appearance of extensive involvement of the calvarium. The lytic areas tend to be ovoid or spherical and vary markedly in size. Some of the numerous smaller areas have coalesced to form the larger punched-out lesions. No marginal response of a reactive nature is evoked



FIG 61 *Plasma cell myeloma in a 40-year-old male* Note the widespread involvement of the ribs and scapulae with multiple small circumscribed areas of bone destruction Pathologic fracture of a rib or compression fracture of a vertebra are often the first symptom of the disease



Fig 62 *Solitary plasma cell myeloma of humerus in a 48 year-old man* The roentgenographic appearance would not permit of this diagnosis since a metastatic lesion could simulate this condition almost exactly At the time this view was made a skeletal survey showed no evidence of any other bone involvement but twenty months later at another institution multiple bone involvement was demonstrated. We have never observed a so-called solitary plasma cell myeloma which if followed over a period of months or years, did not eventually develop multiple lesions and did not progress to a fatal termination.

8

Metastatic Carcinoma

THE numerical importance of bone metastasis as compared with primary bone sarcoma should be emphasized. In patients past the third decade of life there is greater likelihood of a malignant tumor of bone being metastatic rather than primary. Since a complete skeletal survey of patients with carcinoma is not a routine procedure in most institutions, the frequency of bone metastases lacks full appreciation. It is not uncommon to find patients whose initial symptoms are referable to the presence of a metastatic bone lesion but in whom the primary tumor was unrecognized prior to admission. In an appreciable percentage of such cases a complete physical examination will fail to suggest the site of origin nor will a thorough work-up including a roentgenographic study of the chest, intestinal tract, and urinary system necessarily disclose the primary focus, which may remain undetermined until an autopsy is performed.

Whenever a patient who has had a carcinoma subsequently develops a bone lesion there is strong presumptive evidence of metastasis, and roentgenographic studies will offer conclusive proof.

A well known feature of cancers of the breast, prostate, kidney, thyroid, and lung is their predilection for bone metastasis. These tumors are termed *ossophile*. Those which originate in the skin, oral cavity, esophagus, cervix, stomach, and colon show little tendency to spread to bone and are called *ossophobe*. However, any malignant tumor may be associated with skeletal metastasis.

Metastases to bone may be predominantly osteolytic, as with kidney and thyroid, predominantly osteoblastic, as with prostate and breast, or a combination of both. If

treated with radiation therapy or by hormones, there may be a distinct osteoblastic reaction in areas previously osteolytic.

Multiplicity of bone lesions has been described as characteristic of breast and prostatic cancer, while solitary lesions have been considered to be more often the result of thyroid and kidney cancer. While this is often true, exceptions are found often enough to make it unsafe to rely on the number of metastatic lesions in a given case as indicative of their source. The site of skeletal metastasis varies in cancer of different organs; *for example*, prostatic and breast metastases most frequently occur in the spine and pelvis, while the extremities are more often affected by metastases from the kidney and thyroid. Table 1 summarizes the number and percentage of cases that developed skeletal metastases in the total number of cases of cancer of specific organs admitted to Memorial Hospital in 1942.

TABLE 1. *Incidence of Bone Metastasis*
In Series of Cancer Cases Admitted to Memorial Hospital in 1942

Primary site of cancer	*Total cases admitted in 1942*	*Total cases developing bone metastasis*	*Percentage with bone metastasis*
Prostate	31	18	58.06
Kidney	16	7	43.75
Thyroid	20	4	20.00
Breast	626	122	19.48
Lung	87	16	18.39
Soft parts	51	7	13.73
Bladder	37	3	8.11
Testicle	14	1	7.14
Stomach	95	3	3.15
Oronasal	411	10	2.43
Uterus	259	6	2.31
Skin	290	5	1.72
Rectum	225	2	0.88
TOTALS	2,162	204	9.44



FIG 63 *Metastatic breast cancer* Note the location in the distal femur which is unusual The process is osteolytic and rather circumscribed and bears some resemblance to giant cell tumor or central chondroma When such a lesion is discovered in a woman known to have had mammary cancer the diagnosis is relatively easy But occasionally the presence of a primary carcinoma in the breast is not suspected until after the discovery of the metastatic bone lesion and the breast tumor may be quite small and difficult to find



FIG. 64 *Same case as Fig 63 showing metastatic carcinoma of the body of a lumbar vertebra* While considerable bone has been destroyed there is as yet little if any collapse The process is purely osteolytic.

When a single bone metastasis has been discovered, a skeletal survey should be ordered and may often disclose other unsuspected areas.



FIG 65. *Metastatic breast cancer—diffuse* Note the widespread and confluent areas of involvement the lesion is primarily osteolytic. The destruction has produced a pathologic fracture without evidence of repair Osteolytic areas may become markedly osteoblastic under the influence of hormone therapy This case presents features suggestive of plasma cell myeloma (compare with Fig 58)



FIG 66 *Metastatic carcinoma of prostate* The process is typically osteoblastic producing a dense sclerosing area with an ill-defined proximal margin which fades into normal bone by insensible gradations. The presence of the lesion in the distal end of the tibia is unusual

Prostatic metastasis to bone may be osteoblastic or osteolytic; the former phase is far more common and this variety of cancer evokes the most pronounced reactive bone formation of any metastatic process. However lytic areas also are found which tend to become osteoblastic following castration or hormone therapy



FIG 67 *Metastatic carcinoma of prostate* The maximal involvement is seen in the sacrum and right innominate bone. The process is almost entirely osteoblastic but there are small ovoid areas of osteolysis best seen in the right ilium Such cases have been mistaken for osteitis deformans (Paget's disease) as both are associated with a high serum alkaline phosphatase. The acid phosphatase elevation so frequently found in prostatic cancer is absent in Paget's disease The small metallic foreign bodies seen near the right pubis are gold radon seeds which had been implanted in the prostate gland.



FIG 68 *Metastatic carcinoma of kidney* The involved area presents an expansile sponge like complex of destructive and productive features totally irregular and ill-defined. Occasionally this tumor may give rise to a single skeletal lesion. Cases are on record where amputation of such a metastatic area has led to the correct diagnosis and subsequent nephrectomy has been followed by years of survival without further evidence of disease This tumor is known as clear cell renal carcinoma



FIG 69 *Metastatic renal carcinoma of ilium* The process is a solitary one and is destructive without producing expansion its margins are not clear-cut. Frequently the metastasis to bone is the first symptom and the primary kidney tumor is recognized only after further investigation. The patient was a middle-aged woman The roentgenologist could scarcely be expected to foretell the primary site but metastatic carcinoma does seem the most likely diagnosis Myeloma though less probable also has to be considered.



FIG 70 *Metastatic thyroid carcinoma.* A large purely osteolytic lesion with complete destruction of a portion of the crest of the ilium and without expansion of the bone. The primary focus in the thyroid gland was so small that it could easily be overlooked. Patient was a 53 year-old man The thyroid was removed and the histologic appearance of the primary tumor coincided with that which was obtained from the ilium by aspiration



Fig. 71 *Metastatic carcinoma of thyroid (so-called benign metastasizing struma).* This film reveals multiple foci including the right ilium and head and neck of the femur and the left femoral neck which was the site of a pathologic fracture which has healed under treatment. Bone lesions in cases like this one may be discovered from five to ten or more years after thyroidectomy has been performed for what, histologically may have been interpreted as a benign goiter

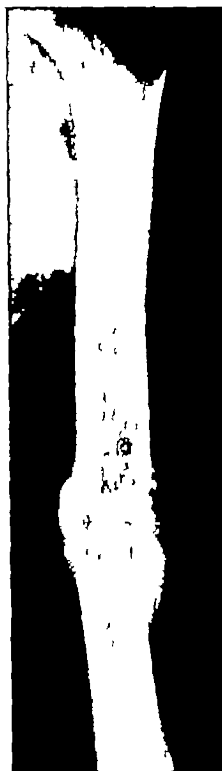


FIG 72 *Metastatic bronchogenic carcinoma.* At first glance, the lesion seems rather sharply limited to a small segment of the humerus however there is a spotty irregular destructive process which extends both proximally and distally for some distance The subperiosteal new bone laid down on the medial aspect of the area of greatest destruction represents callus formation, *i.e* reactive bone about the impending pathologic fracture.

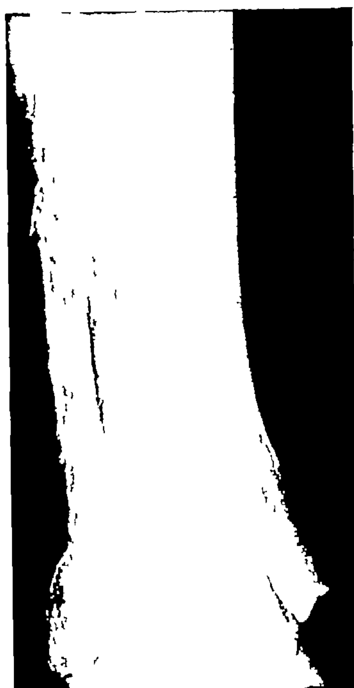


FIG 75 *Metastatic carcinoma of uterus (corporeal endometrium).* The process is almost entirely destructive with only a few wisps of reactive new bone formation In a patient in the cancer age one would consider such a lesion as probably metastatic but the source of the primary growth would scarcely be attributed to the uterus from which bone deposits are seldom seen.



FIG 74 *Metastatic rectal cancer* The mid shaft of the tibia is the site of a bulky soft-part tumor in which fine perpendicular striations of increased density are seen The contiguous portion of the tibia shows erosion

Case of Dr Fred H. Decker and James C Fish Reproduced by courtesy of Eastman Kodak Co.



Fig 75. *Metastatic carcinoma of caecum* The intertrochanteric area and proximal portion of the diaphysis show a mottled osteolytic process which in places involves the cortex and has caused a pathologic fracture with coxa vara deformity Large bowel cancer rarely spreads to bone. Its incidence is less than 1 per cent of all skeletal metastases. It has no peculiarities on roentgenographic study which serve to distinguish it from other forms of metastatic cancer



FIG. 76 *A and B* *Metastatic carcinoma of parathyroid* The right transverse process is greatly expanded and largely destroyed. The entire outline of the bone is distorted. Its inferior border presents an irregular nibbled appearance. Productive or reactive bone is absent. This patient was an adult male with a conspicuous swelling in the thyroid region which, on removal, was found to be carcinoma of a parathyroid gland Biopsy from the vertebral lesion was reported to be of a similar nature

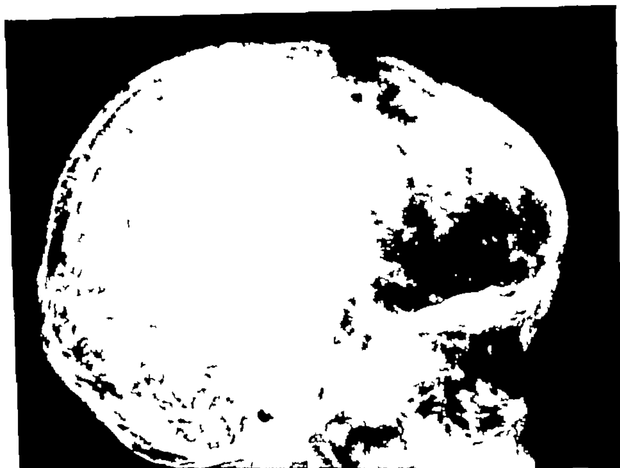


FIG 77 *Metastatic neuroblastoma.* This film shows almost total involvement by a finely distributed osteolytic process The discrete osteolytic areas are minute in size and give the appearance of a sponge like texture Bone production is lacking This patient a child, also presented extensive lesions of the long bones (see Fig. 78)

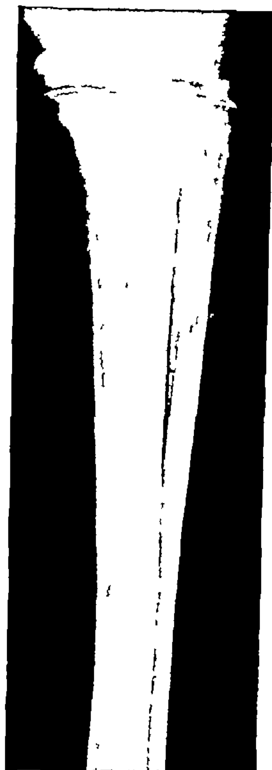


FIG. 78 *Metastatic neuroblastoma (same case as Fig 77)* This tumor is destructive with no appreciable reactive bone The disease is widespread It is frequently mistaken for Ewing's sarcoma and this is one instance in which even the pathologist may find it difficult, if not impossible, to determine from the microscopic sections which of the diseases is present. Skeletal survey is essential If only a single view is obtained the process may resemble reticulum cell sarcoma of bone.



Fig 79 *Hodgkin s disease involving the lumbar spine* This disease may give rise to either lytic or osteoblastic metastases. Here the process is productive rather than destructive In the 4th lumbar vertebra it is spotty in nature while in the 2nd it is more diffuse. Fortunately for the roentgenologist the diagnosis of Hodgkin s disease has usually been established by the time bone lesions are manifest. There is considerable similarity to the deposits of prostatic cancer which however usually occurs later in life than Hodgkin s disease.



FIG 80 *Metastasis to lumbar vertebral body from malignant melanoma* The anterior border of the body is irregularly destroyed and there has been a definite compression with narrowing of the vertebral diameter There is nothing specific about the roentgenographic appearance of metastatic melanoma in bone. Skeletal spread is unusual and the diagnosis has usually been made previous to the discovery of bone deposits.



FIG 81 *Mycosis fungoides of the clavicle* This is a rare bone lesion The normal outline of the acromial end is almost completely destroyed. The involvement is chiefly destructive. There is nothing characteristic about its appearance which would enable one to differentiate it from metastases or other varieties of malignant disease.

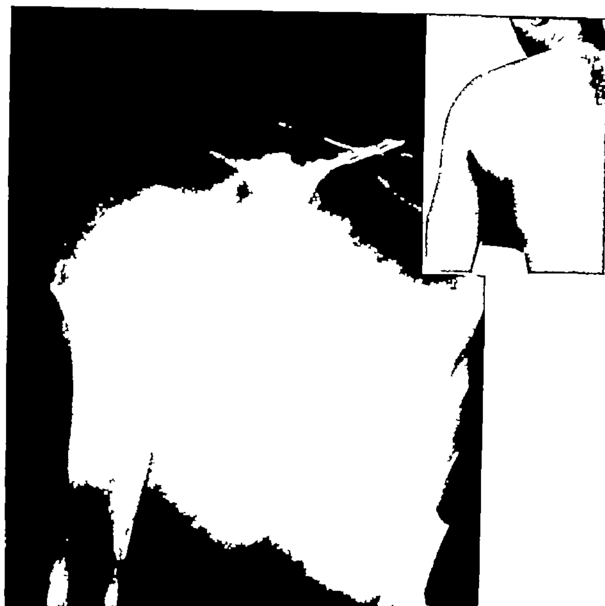


FIG 82 *A and B Malignant synovioma* The unusual feature of this lesion is its extensive bone destruction chiefly of the scapula in addition to the bulky soft part mass It is included here because though synovioma is a lesion of the soft parts, it is frequently associated with bone destruction which makes it necessary to consider it among the bulky tumors with bone involvement in the neighborhood of a joint. Note that the lesion is purely osteolytic. A number of cases have been observed in which the diagnosis of a primary bone tumor was made on clinical and roentgenographic evidence but microscopic examination proved the presence of malignant synovioma.

9

Benign Tumors of Bone

THE roentgenographic features presented by benign tumors of bone are on the whole fairly suggestive if not actually diagnostic. Thus when a lesion of bone presents these characteristics one can usually be quite certain of the diagnosis The comparative mildness of symptoms or even the total absence of complaints is strongly suggestive of a benign condition. When a swelling or abnormal prominence has been known to exist for a prolonged period or has been accidentally discovered by the patient or his family the likelihood is strong that it is benign

In centrally placed tumors the area of bone destruction is usually well circumscribed its outline is smooth and irregular bone destruction is lacking Expansion of bone in the absence of such destruction is a common finding one that is frequently seen in bone cyst giant cell tumor and also in fibrous dysplasia

The benign tumor which most often presents as a projection from the juxta-epiphyseal region of a long bone *i e* an osteochondroma exhibits such a distinctive roentgenographic appearance as to make the diagnosis relatively certain Such tumors when occurring in a paired bone (fibula tibia radius or ulna) may cause distortion of the unaffected bone by prolonged pressure a good example of the plasticity of bone Changes produced by such a benign lesion differ from those exerted by a sarcoma which may actually erode and irregularly destroy the neighboring paired bone

Types of Benign Tumors of Bone

Osteoma	Myxoma
Parosteal Osteoma (juxtacortical low grade osteogenic sarcoma)	Hemangioma
Osteoid Osteoma	Fibrous Dysplasia
Nonosteogenic Fibroma	Solitary Bone Cyst
Osteochondroma	Giant Cell Tumor
Central Chondroma	Adamantinoma
Benign Chondroblastoma	Chordoma

Osteoma

Features which make the diagnosis of osteoma comparatively simple are absence of bone destruction smooth regular outline failure to produce soft-part tumor and a dense radiopaque character of the shadow This type of tumor is relatively rare. The cranial bones and bones of the jaw and face are the most frequent sites. Recently attention has been drawn to a peculiar tumor of the long bones which has been termed by Copeland and Geschickter parosteal osteoma This is a neoplasm which may have a prolonged course tends to recur after incomplete removal and ultimately may metastasize to lungs with fatal outcome

Osteoid Osteoma

There are few lesions of bone which can be correctly diagnosed by means of roentgenograms with greater frequency than can osteoid osteoma The characteristic picture is a zone of dense sclerotic bone often eccentrically placed usually in the shaft of a long bone This zone gradually fades out at the periphery to merge insensibly with normal bone Within the sclerotic area a small irregularly spherical or oval radiolucent nidus may be seen although for its identification exposures of greater penetration may be required than are customarily made. The nidus may appear in the spongiosa or in the cortex. Hence spot films made with considerable penetration are of value. If osteoid osteoma is suspected and initial roentgenographic examination is negative re-examination after a period of a few months should be insisted upon.

Nonosteogenic Fibroma

This distinct entity may be confused with monostotic fibrous dysplasia It is characterized by a radiolucent area which is seen more often in the proximal or distal third of a long bone and in the lower rather than the upper extremity It is irregular in shape frequently eccentrically placed. Its most striking feature is the narrow zone of slightly

increased density at its periphery It is usually symptomless and often discovered because films are made for some unrelated condition It does not tend to expand the bone as is the case with monostotic fibrous dysplasia

OSTEOCHONDROMA

It is seldom difficult to make a correct diagnosis of osteochondroma solely on x ray examination These tumors appear as circumscribed nodular projections. They usually occur near the metaphysis of long bones and their attachment may be by a broad pedicle which merges gradually with the normal bone Occasionally flat bones such as the scapula and pelvis are involved There is generally a mottled calcific deposition which gives a characteristic radiopacity When the lesions are large or if there is a reliable history of rapid increase in size one should be extremely suspicious of a chondrosarcomatous change that may have already taken place. These tumors nearly always have a cartilaginous cap which is poorly visualized on roentgenograms but is readily demonstrated at operation

From the roentgenologist s standpoint the important decision is whether a given case has undergone malignant alteration or is still benign The skiagrams may be more helpful than the microscopic sections in reaching this decision

CENTRAL CHONDROMA, ENCHONDROMA CHONDROMYXOMA

This form of benign cartilaginous tumor is less common than the osteochondroma It is essentially a lytic process and occurs most frequently in the shaft of a long bone where it has a predilection for the metaphyseal area but may also extend to the epiphyseal portion It is the commonest bone tumor of the phalanges of the hands.

When major long bones are affected the possibility of future malignant evolution is always present, the transformation to chondrosarcoma often occurring insidiously

Roentgenographically central chondroma may be mistaken for giant cell tumor fibrous dysplasia or bone cyst however the presence of a fine stippling of calcific deposits within the radiolucent area is characteristic of chondroma and is seldom observed in the other conditions with which it may be confused. The lesion may expand the cortex and even produce a palpable or visible fusiform swelling

BENIGN CHONDROBLASTOMA

This rather uncommon variety of cartilage tumor was first described by Codman who considered it a variant of giant cell tumor but Jaffe pointed out its apparent origin from cartilage germ cells and proposed the term *benign chondroblastoma* It occurs in the age group of 12 to 25 years. 80 per cent of the patients have been males.

It was originally considered to be a lesion peculiar to the proximal end of the humerus but the lower femur and upper tibia may be involved. When it occurs in the humerus, the epiphysis for the greater tuberosity is the portion most prominently involved while that for the head is either spared or only slightly affected

Roentgenographically this tumor presents a fairly characteristic appearance it occurs as a round or oval area epiphyseal or juxta-epiphyseal well circumscribed, not large often eccentric, and with a distinctly mottled appearance due to calcific deposits within the cartilaginous tissue Surrounding the area occupied by the tumor there is condensation of bone similar to that seen at the periphery of an area of attenuated bone infection.

Myxoma of Bone

Considerable doubt exists as to the reality of myxoma of bone as a distinct entity and there are very few references in medical literature since Bloodgood first described it in 1925

Myxomatous degeneration of central chondromas is on the other hand a common finding and the same is true of chondrosarcomas derived from benign chondromas. We have seen only one case in which a diagnosis of pure myxoma of bone could be reasonably supported

Roentgenographic appearances of central lesions containing myxomatous material do not differ from those comprised of pure cartilage. The conclusion is reached that it is not profitable to attempt to separate the myxoma from the chondroma of bone from which it is probably derived by a degenerative alteration

Hemangioma of Bone

The roentgenographic appearance of hemangioma of the spine is diagnostic there are vertical striations due to the loss of the more delicate bone trabeculae between these striations The entire vertebral body is involved and often its vertical diameter *is slightly reduced with a corresponding increase in its* transverse diameter Its contour however is not appreciably changed

Angioma of long bones is a rare condition It is a circumscribed osteolytic process which tends to produce expansion its appearance has been compared by Brailsford to a shaggy head of hair in which there is a centrum with coarse slightly wavy bony trabeculae radiating from it.

Several cases of angiosarcoma of bone have been seen which the pathologist felt had arisen on a pre-existing angioma.

FIBROUS DYSPLASIA OF BONE

This condition appears to be a developmental skeletal anomaly characterized by areas of fibrous tissue in bone These areas may be single or multiple and when multiple may be unilateral or bilateral The lesion is usually first detected in adolescence or early adult life although the Albright syndrome (cutaneous pigmentation sexual precocity in the female and multiple bone areas of fibrous tissue) is usually discovered in childhood

There are several forms of fibrous dysplasia The first is the classical variety referred to above Then there is the monostotic form which lacks cutaneous or endocrine abnormalities A variety of this monostotic form is seen in long bones of an extremity where it occupies a considerable area in the shaft and resembles a bone cyst which has progressed away from the diaphyseal area Finally there is an eccentrically placed lesion called nonosteogenic fibroma of bone by Jaffe which has a fairly distinctive roentgenographic appearance Some authors include this as a variety of fibrous dysplasia while others do not

It is a chronic disease develops slowly and persists throughout life Long bones are principally affected although the skull scapula and pelvis may also be involved

Roentgenographic features are variable cortical erosion from within thinning expansion and a multiloculated or septate appearance are often noted. Hyperparathyroidism is the diagnosis most often erroneously made In the monostotic form of fibrous dysplasia, a giant cell tumor or central chondroma may be simulated In the skull the appearance may be suggestive of osteitis deformans.

SOLITARY BONE CYST

The roentgenographic features of this condition are so constant and characteristic that a diagnosis from the X ray films is seldom difficult. The age of the patient usually ranges from 5 to 15 years The location is uniformly in the metaphysis but it may extend to involve a considerable portion of the adjacent diaphysis The cortex is thinned and the lesion may cause a considerable expansion. There is nearly always a shell of cortical bone left unbroken. Pathologic infractions or even substantial fracture may occur even after trivial trauma in about half of the cases this is the first symptom which discloses the presence of the cyst. While it may simulate giant cell tumor roentgenographically it occurs before the epiphysis is united and on the diaphyseal side while the opposite is true of giant cell tumor

GIANT CELL TUMOR

Despite the fact that the diagnosis of giant cell tumor seldom affords much difficulty to the roentgenologist there are cases encountered with some frequency which resemble central chondroma chondroblastoma of bone bone cyst osteolytic central form of osteogenic sarcoma and rarely solitary myeloma or metastatic cancer

The location is nearly always epiphyseal the proximal end of the tibia and the distal end of the femur and radius are favorite sites. While the cortex offers resistance to encroachment by the tumor it is occasionally completely destroyed but the periosteum forms a limiting membrane which is seldom transgressed The disease rarely ever destroys the articular cartilage instead it may extend to the metaphysis and even to the adjacent diaphysis

ADAMANTINOMA

This condition occurs in the jaw bones the mandible is much more often involved than the superior maxilla It is a lesion of extremely slow growth It presents a central area of radiolucency which is sharply demarcated The edge of the lesion is not irregular or eroded such as is seen in carcinoma invading bone. There is no reactive zone of increased density surrounding it The condition must be distinguished from dentigerous cyst, epulis and fibrous dysplasia.

ADAMANTINOMA OF LONG BONES

Less than 20 cases have been reported of this rare lesion with a single exception (ulna) the tibia was the only long bone affected

In general the same roentgenographic appearance is produced in the long bones as in the jaw We know of no instance where a correct diagnosis of this disease in a long bone was made by means of X ray films.

CHORDOMA

This tumor may occur at any portion of the body which is compatible with its derivation from the primitive notochord The sacrum the spheno-occipital region and rarely the cervical vertebra are the usual sites The process is osteolytic but may be surrounded by a zone of irregular bone production (reactive bone) Roentgenographic examination may not yield a definite diagnosis because similar appearances may be produced by chondrosarcoma, giant cell tumor and metastatic carcinoma



FIG 83 *A and B* *Osteoma* Sharply circumscribed bony projection which appears composed of bone arranged in a normal trabecular pattern The process is purely productive and orderly in its outline It resembles an early osteochondroma but microscopic examination failed to disclose any cartilaginous component. Osteomas are rather uncommon Some undoubtedly arise on a hyaline cartilage basis. They may be classified according to their location as either central cortical endosteal or periosteal Their rate of growth is slow often extremely so and they are painless intrinsically although they may cause discomfort from pressure on overlying soft parts. Long bone osteomas are often spoken of as exostoses and may vary markedly in size and shape (nodular pedunculated pointed etc.)



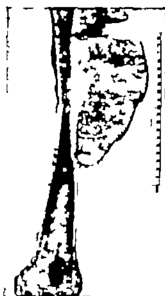


FIG 84 *A and B Parosteal osteoma* Note the dense sclerosing bone with a broad attachment to the femoral shaft. What appears to be involvement within the shaft of the bone is overlying tumor: this can be demonstrated by stereoscopic views The prognosis in these cases following incomplete removal by excision resection etc. is guarded. Continued recurrence in the soft tissues and finally pulmonary metastasis frequently intervene This is the entity which Jaffe terms juxta-cortical osteogenic sarcoma. In the photograph of the gross specimen the marked thickening and eburnation of the underlying cortex are plainly shown. The gap in the upper portion of the tumor represents the area removed for histologic examination after the specimen reached the laboratory



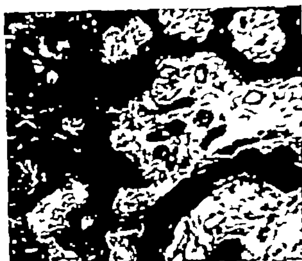


FIG 85, *A and B* *Osteoid osteoma* The features of this lesion are readily apparent. There is a wide zone of homogeneously sclerotic bone which is often asymmetrically placed and which fades out at its periphery by insensible gradations to normal appearing bone This zone involves chiefly the cortex and surrounds a sharply defined radiolucent area of lessened bone density the nidus This lesion is often seen in children less frequently in young adults, and infrequently in the middle aged adult. It affects males in the proportion of 2 to 1 and the ages from 11 to 26 account for three quarters of all cases. It affects the femur and tibia in about half of the reported cases although any bone may be involved cases have been described in the phalanges of the hand and in vertebral bodies.

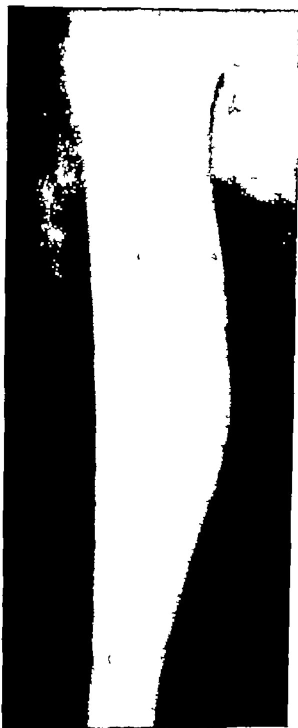


FIG 86 *Osteoid osteoma.* A sclerosing process eccentrically placed in the humerus. The nidus is easily discernible in the center of the lesion. In the absence of a history of *pyogenic osteo-*) *the diagnosis should* not be diffic)
)



Fig. 87 *Another classical example of osteoid osteoma* In this case, however the nidus was not readily seen on films made with routine exposure it required several films of varying degrees of penetration to demonstrate it. When routine films disclose only the zone of eccentric increased density re-examination with films exposed for greater bone detail is indicated.

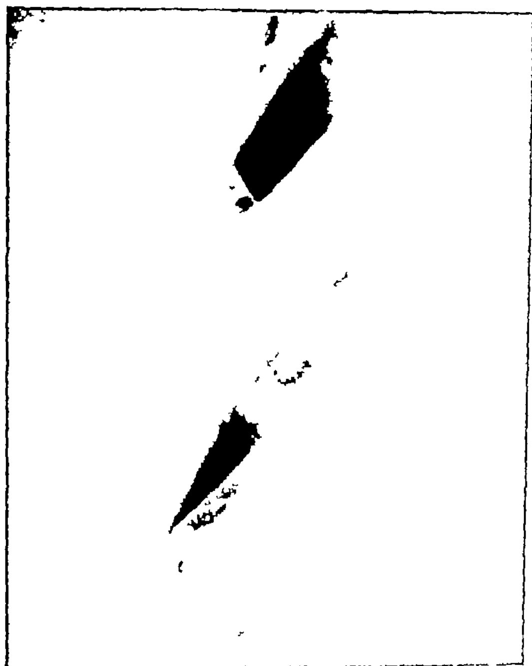


FIG 88. *Osteoid osteoma* This oval circumscribed lesion in the rib presents a much larger radiolucent proportion of the total involved area than is ordinarily seen. There is however a peripheral zone dense sclerotic bone most readily demo strated in the superior margin A rib i most unusual site for this disease

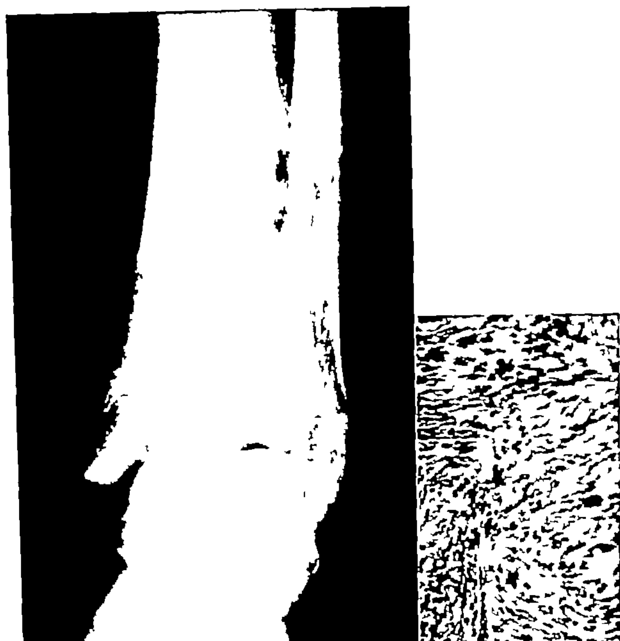


Fig. 89 *A and B Nonosteogenic fibroma of bone* A sharply circumscribed osteolytic lesion in the diaphysis of the distal tibia in a young girl The presence of a narrow zone of increased density about the periphery of the lesion strongly suggests the diagnosis Other bone conditions which on X ray examination may resemble this are fibrous dysplasia, central chondroma, or low-grade fibrosarcoma. The discovery of its presence may be entirely accidental in the course of an X ray taken for some other reason Symptoms are mild or completely absent.



FIG 90 *Nonosteogenic fibroma.* Note the sharply circumscribed, irregularly oval area of lessened bone density about which is evenly disposed a peripheral zone of increased density

This patient was not operated upon and the case lacks microscopic confirmation

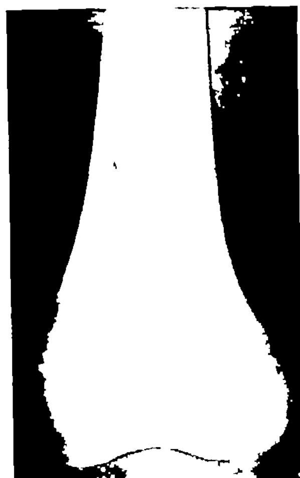




Fig 92 *Osteochondroma of terminal phalanx of toe* The trabecular pattern is relatively normal This is not the type of lesion in which malignant degeneration is prone to occur Deformity and discomfort due to pressure of the shoe may make removal justifiable.

These tumors are probably of congenital origin in most instances. They may exist for many years with little change and slight or no inconvenience. When they exhibit a change in growth rate or give rise to pain the possibility of chondrosarcomatous alteration should be seriously considered

Fig 91 *Nonosteogenic fibroma of bone* The contour of the femur is not altered the lesion is sharply circumscribed irregular in shape, and purely osteolytic except for a narrow peripheral zone of increased density No microscopic confirmation



FIG 93 *A and B Osteochondroma of distal end of tibia.* Note its juxta-epiphyseal location and the fact that it is sharply circumscribed but has produced deformity of the distal end of the fibula due to pressure. A somewhat similar tumor is depicted in Fig 94 The epiphyseal line of both bones is intact and the ankle mortice is not widened.



Fig 91 *Osteochondroma of distal end of tibia.* The process is coarsely trabeculated and sharply circumscribed and involves only a small portion of the breadth of the bone. Due to pressure the adjacent area of the fibula shows striking deformity and eburnation These changes indicate a slowly growing tumor which has caused bending but not destruction of the fibula.







FIG 95 *A B and C Osteochondroma.* The proximal end of the humerus is a favorite site for a single osteochondroma. The degree of involvement of the humeral shaft is extreme While benign in childhood and often until middle adult life or later the ultimate prospect of a secondary chondrosarcomatous change is not remote Note the purely metaphyseal and diaphyseal location of the process the humeral head and epiphyseal line are intact. There is only a narrow zone of cortex on the lateral aspect which remains intact Resection of the tumor therefore entails risk of pathologic fracture and in any event bone transplantation is essential after resection to achieve a satisfactory end result. Such a procedure was satisfactorily carried out in this case.



FIG 96 *Hereditary deforming chondrodysplasia diaphyseal aclasis* The process is deforming rather than destructive appears in the juxta-epiphyseal portion of long bones and is multiple (as in this case) Skeletal survey of long bones is indicated. Because of the fact that secondary chondrosarcoma may develop in one of these areas, patients with this affliction should be observed at regular intervals and should be warned to report any gross alteration or change in their symptoms. Usually the process is relatively stationary This patient was a young girl.



FIG 97 *Multiple cartilaginous exostoses Same case as Fig 96* The metaphysis of almost every long bone was affected in this case. Note the irregular projections with sharp outline and apparently normal bone texture The cartilaginous cap which overlies most of these projections is usually associated with a bursa The condition is distinctly hereditary It has appeared however in many instances in individuals where the family history as far as could be traced, was entirely negative.



FIG. 98 *Same case as Figs 96 and 97* Bulky osteochondroma of proximal end of fibula extending well into the soft tissues. The tumor is stippled with flecks of calcific material but has a rather sharply demarcated border This type of tumor often causes symptoms due to pressure on nerves or blood vessels. This was the presenting lesion on admission and without skeletal survey could be considered as a solitary osteochondroma. A lesion as bulky as this should be resected and this one, as opposed to the others present in this patient, seems the most likely one to undergo malignant transformation at some future date



FIG 99. *Central chondroma* The most common central lytic lesion of a phalanx is enchondroma. The cortex is thinned and expanded. Frequently minor cortical infractions are seen as the result of trivial trauma The tumor may present areas of calcific stippling which are characteristic of cartilage tumors though in this instance they are not prominent. Unlike central chondromas in other long bones, those in the phalanges practically always remain benign we have never observed one in which there was a transition to chondrosarcoma Curettage and replacement with bone chips is a successful method of treatment.



FIG 100 *Central chondroma (enchondroma) of humerus a fairly typical example of the roentgenographic appearance of this condition* There is well localized bone destruction but in addition there is a calcific mottling present both above and below the principal area of bone destruction which represents calcified cartilage This patient was an adolescent female. Three unsuccessful attempts at cure by curettage were finally followed by wide segmental resection with massive graft and an excellent result was obtained which has been maintained for twenty years.



FIG 101 *Central chondroma (enchondroma).* This lesion resembles a giant cell tumor or an osteolytic form of osteogenic sarcoma. It is, however limited to the juxta epiphyseal portion of the humerus and the margins are sharply outlined with slight peripheral reactive bone There appears to be a break in the cortex on the medial aspect of the neck No soft tissue extension is seen The tell-tale feature of calcific deposits which appear as mottled areas of irregular increased densities is notably absent in this case which makes a roentgenographic diagnosis of central chondroma difficult.



FIG 102 *A and B Benign chondroblastoma (Codman's epiphyseal chondromatous giant cell tumor)* This tumor which is *not* a giant cell tumor but a neoplasm of cartilaginous derivation is usually found in the head of the humerus but may also occur in the distal femur or proximal tibia The degree of expansion of the cortex is less pronounced than is sometimes seen in benign giant cell tumor However the cortex is thinned and multiple ovoid or spherical areas of bone destruction are seen. Areas of calcific stippling not evident in this film are strongly corroborative of the diagnosis. Curettage and bone chip implantation yielded a successful result in terms of a seven year follow-up

The microphotograph reveals an irregular cytology which in the past has been confused with osteogenic sarcoma There is formation of osteoid and cartilaginous tissue with scattered epulis type giant cells. This is not a metastasizing tumor



FIG 103. *Myxoma of bone* This is an exceedingly rare primary bone tumor Its appearance and location suggest an early giant cell tumor It is purely osteolytic and there is no marginal reactive bone formation Biopsy is required to establish a precise diagnosis in a lesion of this sort. We suspect that the lesion actually commenced as a chondroma and underwent complete myxomatous degeneration Curettage was successful and a fifteen year follow up shows no evidence of disease



FIG 104 *Hemangioma of lumbar vertebra* Note the characteristic preservation of the bone traberulae in a vertical fashion with interposing areas of osteolysis which is characteristic of angioma of the vertebra. No microscopic confirmation Despite the degree of involvement, there is no apparent collapse.

The patient was a middle aged woman Roentgen therapy was employed and there was a twelve year follow up with relief of symptoms. Hemangioma of a vertebral body is said by some observers to occur in 10 per cent of individuals autopsied It is also said to have a higher incidence with advancing years (4 5 per cent under 20 years as compared with 36 per cent over 50 years) These figures may be misleading and it is certainly seldom picked up by X ray examination during life While no collapse of the body has occurred in this vertebra, such may take place and cord symptoms may then develop

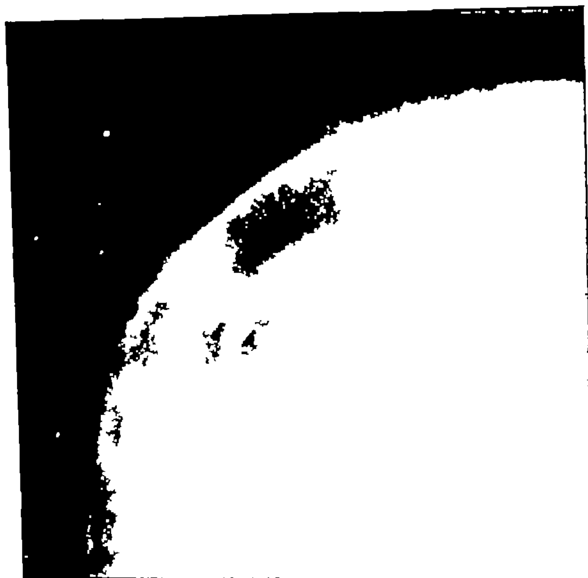


FIG 10~~y~~. *Hemangioma of skull* Although perhaps difficult to describe, the appearance of this tumor is quite charac teristic. Tangential views should always be obtained and may give additional informa tion In lesions of this sort one must also consider the possibility of a meningioma. The pathologist reported "cavernous he mangioma"

Hemangioma of the skull may remain apparently stationary for long periods and be symptomless except for the presence of a slight convexity of the outer table The frontal and parietal bones are favored sites. The roentgenographic features are rather consistent and characteristic. There is a finely mottled osteoporosis resembling foam rubber with spicules of bone radiating from the surface of the growth producing a striated appearance



Fig 106 *A and B Hemangioma of bone* This distinctly circumscribed tumor arising from a metatarsal has grown over the neighboring uninvolved bones covering them as with a cloak. Where the lesion is best seen in profile its structure is a sponge like or honey-comb arrangement. Symptoms are usually of long standing and consist of swelling and a dull aching pain in the involved region In this case local resection was not successful and a subsequent Syme amputation was performed with good result.





Fig 107 *A and B* *Hemangioma of the clavicle* Note the irregular destruction and production of bone going on coincidentally This tumor is rarely encountered in long bones. The roentgenographic features are variable. Compare with Fig 106 The pathologist reported capillary and racemose hemangioma

The photograph of the gross specimen shows bulky soft part extension of the tumor which is not apparent in the roentgenogram.

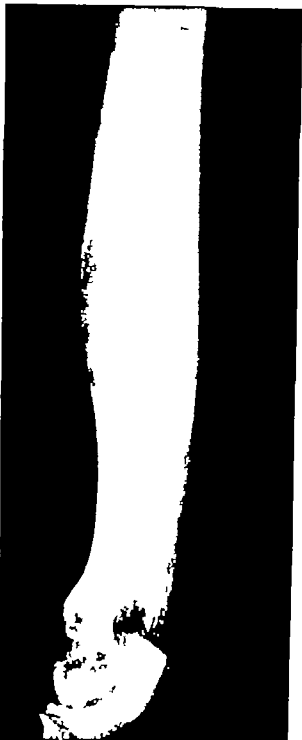


FIG 108 *Fibrous dysplasia polyostotic form* There is expansion of the mid shaft of the humerus in a sharply circumscribed area which is oval in shape. The distal portion of the lesion is radiolucent while the proximal portion is homogeneously sclerotic. Other lesions were present in the radius and one rib

This disease is most often identified in the third decade and affects women more frequently than men in the proportion of 3 to 1 It is a chronic disease, developing slowly but persistently through life. Long bones are conspicuously affected although pelvic bones, skull, and scapula may be involved. Conditions which resemble fibrous dysplasia are hyperparathyroidism bone cyst, nonosteogenic fibroma and enchondroma Of these the most frequent error has been to regard the lesions of fibrous dysplasia as manifestations of hyperparathyroidism.



FIG 109 *Polyostotic fibrous dysplasia* Note the marked alteration in the normal architecture of the femur and pelvic bones with extreme thinning of the cortex and coarse trabeculation with radiolucent spaces. The spongiosa is thus largely destroyed. Pigmentation of the skin was also present. The patient was a 20-year-old man.

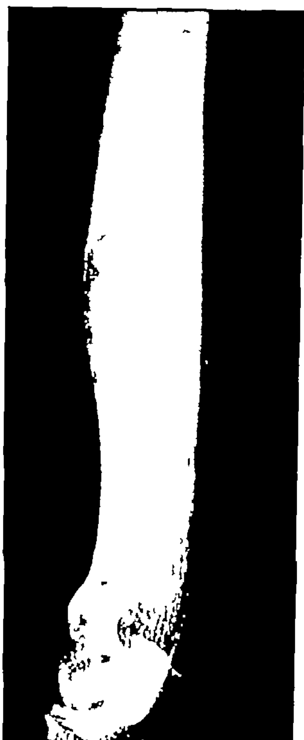


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FIG 110 *Polyostotic fibrous dysplasia (same case as Fig 109)* Many bones were affected in addition to the calvarium. The mottled effect is produced by the osteoblastic and osteolytic properties of this lesion The combined effect is totally irregular and gives rise to pronounced deformity of the head. The only other condition which may produce such extensive changes of a mixed productive and destructive nature is osteitis deformans. The details of the roentgenographic appearance should make a distinction relatively simple.



Fig. 111 *Solitary (unicameral) bone cyst* This lesion is typical as it occupies the metaphysis and part of the diaphysis is purely osteolytic, shows considerable expansion with thinning of the cortex and a slight tendency to bony trabeculation.

Solitary bone cyst has its onset in childhood or adolescence prior to the closure of the epiphysis. This is the feature which distinguishes it from giant cell tumor to which in other respects it superficially bears a close roentgenographic resemblance The proximal end of the humerus is the favored site (22 out of 52 cases personally observed) the proximal end of the femur is the next most common location It is an entirely benign disease and should always be treated by conservative surgery



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FIG 112 *Solitary (unicameral) bone cyst* Relatively symptomless lesion in a child The sharply delimited purely osteolytic area in the metaphysis is characteristic. This must be differentiated from central chondroma or fibrous dysplasia Sometimes a bone cyst with slight cortical infraction with repair at the site of such infraction may superficially resemble a medullary fibrosarcoma.

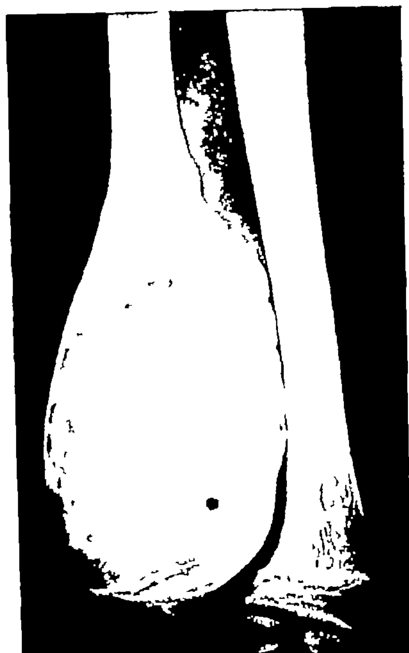


FIG. 113 *Solitary (unicameral) bone cyst* The location in the distal ulna and the size are unusual There was a period some years ago when such a process might have been termed *giant cell variant of bone cyst* However the age of patient and the metaphyseal location without involvement of the epiphysis are features which should make the diagnosis of bone cyst relatively easy even though the pathologist may find giant cells in tissue removed at operation



FIG. 114 *Solitary (unicameral) bone cyst* Septate osteolytic lesion confined to the metaphysis in a subject whose epiphyses have not yet closed. The distal humerus is seldom affected. The similarity in roentgenographic appearance to giant cell tumor is marked.



Fig 115. *Benign giant cell tumor* Note the location in the epiphysis, the fact that the tumor's origin is in the lateral tuberosity and that it encroaches on but does not involve the articular cartilage There is a tendency to bony trabeculation and the process is entirely osteolytic, but without expansion of the thinned cortex The roentgenographic features of this disease are so clear-cut and well defined that a diagnosis can be made relatively easily on the basis of films alone The location in the epiphyseal region its circumscribed osteolytic character its tendency to expansion with thinning of the cortex are characteristic Even when no vestige of the cortex is visible the soft part shadow is closely confined by the overlying periosteum. Trabeculation (soap-bubble like septa) is often mentioned as a characteristic but is rather infrequently seen.



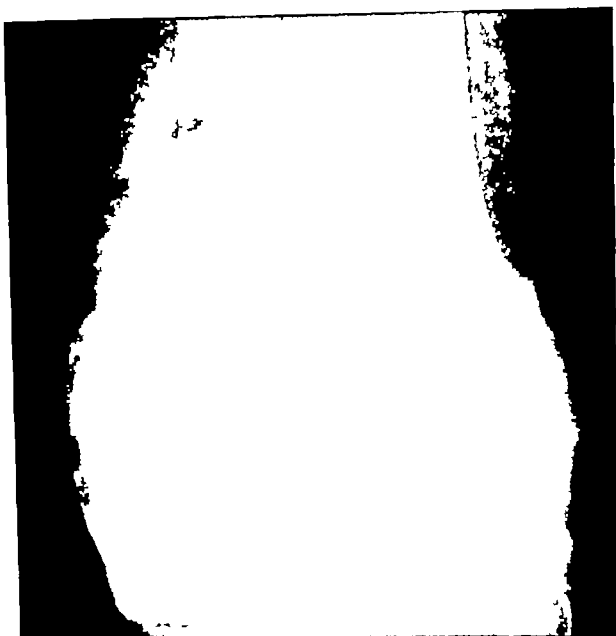


FIG. 117 *Benign giant cell tumor in a man aged 42* In this age group these tumors are apt to be more aggressive than in the younger age group. The lesion has begun in one condyle and has slowly extended beyond the midpoint of the lower end of the femur The process is purely osteolytic but lacks the trabeculated appearance often regarded as typical of this lesion Actually the roentgenographic appearance of this particular tumor can be closely approximated by osteolytic osteogenic sarcoma or even metastatic cancer



FIG 118 *Giant cell tumor of os calcis* Osteolytic area in os calcis with little alteration in the shape of the bone but with diffuse lytic changes that have altered the normal trabecular pattern Microscopic confirmation would be required The tarsal bones are seldom the site of this tumor

When giant cell tumor affects flat bones or other than the major long bones, its diagnosis on roentgenographic appearances is less accurate.



FIG 119. *Giant cell tumor of fourth metacarpal an unusual location for this disease* Most of the shaft and distal end of the bone is affected. There is expansion of the markedly thinned cortex. This appears unbroken A more common destructive lesion in this location from which giant cell tumor must be distinguished is central chondroma However the marked thinning and expansion of the cortex seen in this case is not typical of central chondroma. Bone cyst and fibrous dysplasia are most unusual in this location.



FIG 120 *Subperiosteal giant cell tumor of bone in the shaft of the femur* Such a location is exceedingly rare. Note the eccentric position of the lesion the comparative lack of cortical involvement, its sharp delimitation and the reactive triangles of bone at either margin Trabeculations are not present the lesion is osteolytic. The pathologist reported "benign aneurysmal giant cell tumor"



Fig. 121 *Giant cell tumor of an unusual type* Note that the lesion is situated lower in the tibia than the average giant cell tumor that it is further from the epiphysis, and that it is eccentric and resembles Fig 120 which presents a somewhat similar appearance in the shaft of the femur The pathologist reported "fibrosing ossifying giant cell tumor"

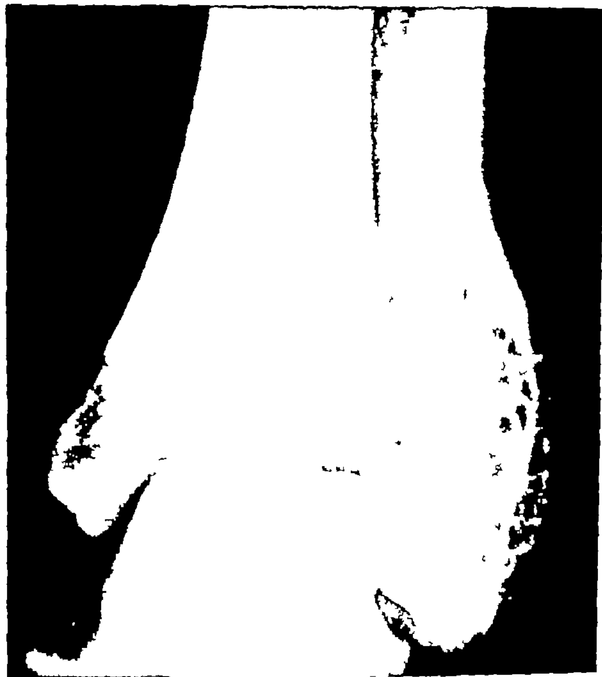


FIG. 122 *Giant cell tumor* Typical features include an osteolytic lesion with marked expansion of the cancellous bone of the distal fibula There is a pronounced septate pattern. The pathologist reported "fibrosing sclerosing ossifying giant cell tumor"



FIG 123 *A B C and D Extensive adamantinoma of mandible* The margin of the tumor posteriorly is sharply demarcated from adjacent uninvolved bone. The affected portion extends to involve both right and left rami and symphysis. The tumor presents residual bone disposed in flame like strands arranged in a totally irregular fashion. Adamantinoma lacks any osteoblastic properties. Roentgenographic features are a mono- or polycystic medullary process with sharply demarcated zones of radiolucency There is little or no reactive marginal bone and the irregular eroded edge seen in carcinoma invasion of bone is lacking The conditions most often mistaken for adamantinoma are epulis, dentigerous cyst and fibrous dysplasia.

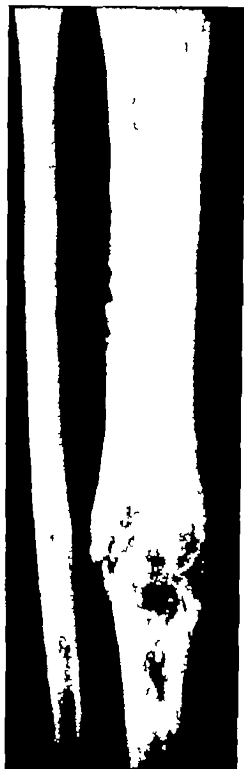


FIG 124 *Adamantinoma of tibia A curious roentgenographic appearance characterized by marked but somewhat circumscribed bone destruction and dense sclerosing reactive bone The presence of a bizarre lesion in the tibia should make one somewhat suspicious of this very rare long bone* manifestation of a disease usually confined to the jaws. Excluding adamantinoma of th jaw bones all other reported cases of adamantinoma have been located in the tibia *with one exception a case which arose* in the ulna

In tibial lesions a correct roentgenographic diagnosis of adamantinoma would be an achievement Treatment by conservative surgery is difficult since the entire tumor bearing area must be excised, or else recurrence will result. As in mandibular adamantinoma, the disease progresses with extraordinary slowness (up to twenty or more years) The reason for the location of this tumor almost exclusively in the tibia (excepting of course the jaw bones) is still unexplained



FIG 125 *Sacral chordoma* Note that the normal configuration of the sacrum has been markedly distorted by the process which has produced irregular bone destruction and which presents a somewhat loculated appearance The sacrum has been expanded and yet the process has many X ray features of a benign tumor since the destruction is not like that in osteolytic tumors of a malignant form such as chondrosarcoma or reticulum cell sarcoma

Chordoma may occur at any age from infancy to nearly 80 The disease is most often found in patients over 50 Males are afflicted more than twice as often as females. The sacrococcygeal region accounts for about three fifths of all cases the cranial and cervical cases constitute the bulk of the remainder with only occasional rare examples in the thoracic or lumbar spine

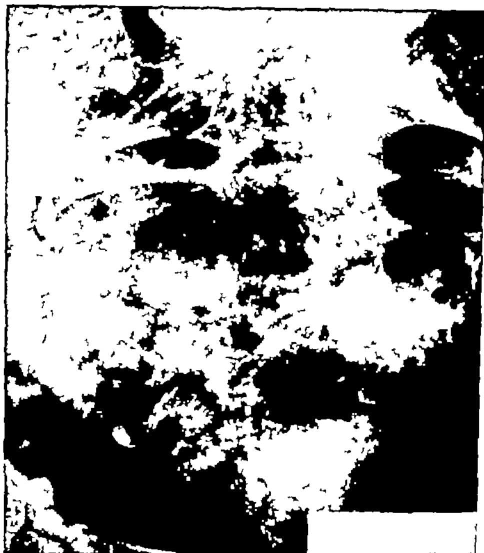


FIG. 126 *Sacral chordoma* There is loss of normal outline of the distal sacral segments due to a purely destructive lesion Here, the features of chordoma are not sufficiently distinctive to permit a ready differentiation from metastatic cancer or medullary chondrosarcoma. Microscopic confirmation is essential.

The lesion is considered benign and metastasis to lungs is rare but does occur Despite its benign character it grows relentlessly though slowly and gives rise to great pain in its later stages. When the tumor involves only the lower sacral segments, it is possible to resect it completely with an excellent prospect of cure When the upper segments are invaded, radical surgery is not feasible and incomplete removal does not accomplish much Unfortunately these tumors are radioresistant. In selected cases cordotomy is to be recommended for relief of pain



FIG 127 *Epidermoid cyst* The lesion seen in the terminal phalanx is expansile has thinned the cortex and caused it to bulge. It had been considered an enchondroma prior to operation the condition with which it is most often confused However the pathologist reported a lining membrane of stratified epidermal epithelium surrounding a caseous material which represented exfoliated cells and debris.

This is a rather rare condition and all reported cases have been located in the terminal phalanx. They always follow an injury either of a crushing or penetrating nature The evolution is slow In this case the roentgenogram was made two years after the accident.



FIG 128 *Giant cell tumor of tendon sheath* Lytic areas in the distal end of the middle phalanx caused by extension of a xanthoma of tendon sheath origin (giant cell tumor of tendon sheath) At operation the bulky soft part tumor was found to have eroded the bone by pressure and its removal left a smooth bi lobed concavity



FIG 129. *Schwannoma involving bone* Sharply circumscribed well-defined lytic area at the proximal end of the proximal phalanx of the index finger There are no trabeculations which might suggest a giant cell tumor and there is no calcific stippling which would favor an enchondroma. The lack of expansion makes giant cell tumor less likely The roentgenographic features suggest a benign lesion which was borne out by the microscopic report of schwannoma. This tumor rarely involves bone.

10

Non-neoplastic Conditions of Bone Simulating Bone Tumors

WHEN films reveal a lesion of bone the first step is to decide whether it is a tumor or one of the many nontumorous conditions which may at times closely resemble true neoplasms as shown in Table 2

TABLE 2 *Non neoplastic Conditions of Bone Sometimes Confused With Tumors of Bone*

Non-neoplastic conditions	*Bone tumors*
INFECTIONS	
Pyogenic	Ewing's sarcoma (endothelioma)
Typhoid	Myeloma
Tuberculosis	Myeloma (spine) Chondrosarcoma
Syphilis	Osteogenic sarcoma
Yaws	Osteogenic sarcoma Endothelioma, in children
Chronic sclerosing osteitis	Sclerosing osteogenic sarcoma
Mycotic infections	May simulate many malignant bone tumors
PARASITIC DISEASES	
Hydatid disease	Osteolytic osteogenic sarcoma Chondrosarcoma Metastatic carcinoma

TABLE 1 *Non neoplastic Conditions of Bone (Continued)*

Non neoplastic conditions	*Bone tumors*
GRANULOMATOUS DISEASES OF UNCERTAIN ETIOLOGY	
Letterer Siwe disease	Metastatic neuroblastoma
Hand-Schüller-Christian disease	Metastatic neuroblastoma
Eosinophilic granuloma	Ewing's sarcoma Metastatic carcinoma Osteolytic osteogenic sarcoma Myeloma (in later life)
LIPID STORAGE DISEASES	
Gaucher's disease *Niemann Pick disease*	Medullary fibrosarcoma Metastatic carcinoma Metastatic adrenal neuroblastoma
ENDOCRINE DISEASES	
Hyperparathyroidism	Metastatic carcinomatosis
DISEASES DUE TO CIRCULATORY DISTURBANCES IN BONE	
Aseptic necrosis	Benign chondroblastoma
Calcinosis (*tumoral form of Inclan*)	Sclerosing osteogenic sarcoma Calcifying chondroma
DISEASES DUE TO TRAUMA	
Ossifying hematoma (in early stages) Fatigue fracture active reparative stage Periosteal tears active reparative stage	Osteogenic sarcoma
DISEASES OF UNCERTAIN ETIOLOGY	
Osteitis deformans (Paget's disease)	*Prostatic carcinoma metastases*
Leontiasis ossea	Low-grade osteogenic sarcoma of facial bone
Melorheostosis	Parosteal osteoma Osteogenic sarcoma low grade
Phantom bone (spontaneous absorption of bone)	Osteolytic osteogenic sarcoma Metastatic carcinoma
Infantile cortical hyperostosis	Osteogenic sarcoma
Agnogenic myeloid metaplasia	Metastatic cancer

Since these diseases roentgenographically may simulate tumors of bone the surgeon or radiotherapist may have occasion not only to diagnose but also at times to treat them. Furthermore some of them have been found to be complicated by superimposed malignant *tumor involvement*. *This is* particularly true of osteitis deformans (Paget's disease) but is rarely the case in connection with osteopetrosis, aseptic necrosis or myositis ossificans

The importance of this group of miscellaneous skeletal diseases from the stand

point of differential diagnosis varies greatly with the individual conditions Some are rarely seen in the United States but are common in other countries (hydatid disease yaws) others are so rare in any locality that their inclusion might seem of question able propriety (osteopetrosis spontaneous absorption of bone) On the other hand osteomyelitis granulomatous conditions (eosinophilic granuloma Hand Schüller Christian s syndrome) myositis ossificans and others are encountered comparatively often Yet films of all of the diseases mentioned have been mistaken for some type of bone tumor and for that reason have seemed to merit inclusion in this treatise

PYOGENIC INFECTIONS

Hematogenous Osteomyelitis

The sudden onset profound constitutional reaction severity of symptoms and signs which are associated with acute fulminating cases of osteomyelitis, make its confusion with neoplastic disease most unlikely

Cases of milder infection with insidious onset may on the other hand present symptoms and signs that are local and when seen at a time when the earliest recog nizable roentgenographic signs are evident may lead to an incorrect diagnosis

Hematogenous osteomyelitis and bone sarcoma have the following features in com mon both occur in childhood and adolescence both present the same triad of pain swelling and disability both may be associated with a history of local antecedent trauma and the sites commonly affected are the same. Fever and leucocytosis are con stant findings in osteomyelitis, and while seldom seen in osteogenic or chondrosar coma, are often present in Ewing s sarcoma Indeed the distinction between the lat ter tumor and osteomyelitis may at times be almost impossible on the basis of X ray examination and clinical findings.

When seen in the later stages of the infection osteomyelitis will present X ray changes which are less and less suggestive of Ewing s sarcoma. Since the incidence of osteomyelitis decreases rapidly after the age of 16 it is a problem of differential diag nosis chiefly in childhood.

Central Bone Abscess (Brodie s Abscess)

This form of bone response to infection is usually limited to a single bone most often the tibia, although other major long bones may be affected. It is usually ob served in children adolescents or young adults. The site of the abscess is the medul lary portion of the metaphysis. The epiphysis protected by the epiphyseal cartilage, is seldom involved The pus is contained in the medullary cavity and does not form a

subperiosteal abscess Dense sclerotic bone often surrounds the abscess and may be a very prominent roentgenographic feature at times the appearance is quite similar to that seen in osteoid osteoma. In other cases the area of radiolucency is much larger and the peripheral zone of increased density may be much narrower giving it the appearance of a nonosteogenic fibroma.

TYPHOID INFECTION

Typhoid Infection in Bone

In the United States at least the reduction in the incidence of typhoid fever has now reached a point where it is actually a rare disease And since bone infection due to the *Salmonella typhosa* organism was always an infrequent complication, even when the disease itself was common it is obvious that bone lesions of typhoid origin are now exceedingly rare. We can recall only one case. There was a small area of rarefaction in the proximal end of the femur which did not present any striking features on the roentgenogram. It had been biopsied and the pathologist was puzzled by its microscopic appearance which at first suggested some atypical form of myeloma.

This is mentioned here for the sake of completeness and to illustrate the need for taking a careful history in every case that presents a lesion in bone.

TUBERCULOUS INFECTION

Tuberculosis of Bone

Tubercular involvement of bone is another disease which in the United States at least, seems to be steadily on the decline In countries where it is still common it is a condition which may give rise to difficulties in roentgenographic interpretation. Girdlestone says that secondary carcinoma or bone sarcoma can almost always be distinguished from tuberculosis by radiography When as occasionally happens tuberculosis affects an area in the shaft of a long bone at some distance from the joint it may present features which are so similar to osteogenic sarcoma, Ewing's sarcoma or reticulum cell sarcoma as to require the assistance of pathologic examination of biopsy material to establish the diagnosis. Joint involvement not uncommon in tuberculosis rarely occurs in malignant bone tumors

SYPHILITIC INFECTION

Syphilitic Osteitis

Luetic osteitis a tertiary manifestation of the disease appears to be decreasing in frequency in urban areas of the United States It is still a condition to be considered in connection with a suspected bone neoplasm for it can mimic a variety of other bone diseases including tumors

Involvement may be confined to a small area in a single bone be widespread throughout an entire bone or appear as scattered areas in several bones. Congenital syphilis shows a predilection for the nasal bones phalanges and radius Serologic tests are desirable in every case of suspected bone tumor but a positive reaction of course does not exclude the presence of an incidental bone tumor In addition to other inflammatory diseases osteitis fibrosa cystica giant cell tumor and primary and metastatic malignant tumors may present roentgenographic appearances which syphilis can simulate

Perhaps one of the most difficult problems can be posed by the so-called Charcot joint which is, on X ray examination compatible with a destructive malignant tumor either metastatic or primary in bone or involving bone by extension (synovioma)

In tropical countries yaws is a closely allied infectious disease caused by *Treponema pertenue* Serologically and morphologically indistinguishable from syphilis it is not capable of producing congenital disease but children may contract it early in life. During its tertiary stage bone lesions are common Helfet in describing the acute manifestations of bone and joint yaws considers it the most ubiquitous tropical disease of these structures The tibia clavicle (inner end) and humerus (lower third) are favorite sites. Serology is always positive Bone lesions invariably fail to ulcerate through the skin. The roentgenographic appearance closely resembles that of syphilis including widening of the shaft areas of dense sclerosis, and others with areas of punched-out radiolucency In the acute form there is evidence of subperiosteal necrosis elevation of the periosteum with expansion and new periosteal bone formation which may be laid down in the lamellated fashion often seen in Ewing's sarcoma (onion layer appearance) Occasionally the newly deposited bone may be suggestive of osteogenic sarcoma.

Untreated inactive yaws of long standing may resemble a sclerosing osteogenic sarcoma or a chronic sclerosing osteitis of Garré But in children in tropical countries there may be difficulty in distinguishing yaws from osteogenic sarcoma or Ewing's sarcoma

MISCELLANEOUS INFECTIONS

Chronic Sclerosing Osteitis

A lesion which may infrequently require differentiation from sclerosing osteogr sarcoma is chronic nonsuppurative sclerosing osteitis first described by Carré 1893 Prior to Jaffe s first description of the condition which he termed *oste osteoma* the medical literature contained a number of case reports of Garré s ease which most observers now believe were mainly actual examples of oste osteoma. Brailsford the distinguished British roentgenologist, still maintains t the entity now accepted as osteoid osteoma is actually a chronic low-grade inflam tory lesion or perhaps a subcortical bone infection There are several features the condition which are indeed difficult to reconcile with a neoplastic origin.

The roentgenologist who is called upon to render an opinion will be on s ground if he makes a diagnosis of osteoid osteoma in preference to that of chro sclerosing osteitis

Mycotic Infections of Bone

Of the rare bone infections of the mycotic or granulomatous type the follow should be mentioned actinomycosis blastomycosis coccidiomycosis, sporotricho maduromycosis and torulosis. Our experience with the roentgenographic interpre tion of bone changes seen in this group is exceedingly limited All of these infecti produce irregular osteolytic areas in the bone which are often multiple though sufficient reaction in the adjacent bone may be induced to bring about sclero Alteration in the contour of the affected bone is not a prominent feature. T presence of the underlying disease if known, is of course most helpful and if it is r suspected, a roentgenographic diagnosis may be most difficult. *Biopsy discloses an* flammatory type of tissue while bacteriological study usually leads to a corr diagnosis

Roentgenologists should report more individual cases with reproduction of fil so that the profession may become better acquainted with the features seen on t roentgenogram

Sarcoidosis (Boeck s Sarcoid) of Bone

The fact that bone lesions of sarcoidosis are usually small multiple and most oft seen in the small bones of the fingers and toes is helpful in establishing the X r diagnosis of this disease

Sarcoidosis is comparatively uncommon and its etiology is still unsettled by some it is thought to be due to a nonvirulent tubercle bacillus by others to be an infectious granuloma caused by a virus Negroes seem to be especially susceptible although the disease is certainly not confined to that race Besnier found bone lesions present in nine out of 35 cases

The medullary portion of the bone is involved and cyst like radiolucent areas are typical sometimes these are surrounded by a zone of increased density

PARASITIC DISEASES

Hydatid Disease

Echinococcus infestation is not endemic in the United States and most of the patients seen here acquired their infection elsewhere. Only about a dozen cases with bone involvement have appeared in the American medical literature. There are however other countries where the disease is not uncommon and bone manifestations require recognition by the roentgenologist. Australia Argentina parts of China and the Mediterranean countries and the Middle East are among the more prominent foci of this disease

We have encountered two cases with bone involvement and in both the condition was considered to be a neoplasm of bone until microscopic examination disclosed the typical hooklets scolices and chitinous membrane

The ilium and vertebrae account for more than half of the cases the humerus tibia and femur are also common sites whereas any other location is rare. Bone involvement is always of long duration as the parasite exhibits great latency in skeletal tissue

The roentgenographic appearance is bizarre and may resemble osteomyelitis, metastatic cancer osteogenic sarcoma, chondrosarcoma, or myeloma.

GRANULOMATOUS DISEASES OF BONE OF UNCERTAIN ETIOLOGY

Letterer Siwe Disease

This condition called *aleukemic reticulosis* by Letterer *diffuse reticuloendotheliosis* by Siwe and *nonlipid histiocytosis* by Foot and Olcott is a rapidly fatal infantile disease Bone lesions are not prominent and the roentgenologist is seldom called upon to render the diagnosis

HAND-SCHULLER CHRISTIAN DISEASE

The onset is insidious It is usually seen in infants and children but may occur in adults The bone lesions are a prominent feature and may be the presenting symptom The skull bones are the frequent site of osseous lesions although the long bones vertebral bodies ribs maxillae pelvic bones and scapulae may also be affected. Any portion of the calvarium may be involved and both tables are usually destroyed. The appearance of the areas of bone destruction as seen on X ray films is rather characteristic. Margins are sharply defined and resemble cystic areas but the irregular shape of the radiolucent areas especially in the calvarium are almost pathognomonic. Vertebral bodies are prone to collapse but cord compression is unusual. When the classical triad of symptoms is present, the diagnosis is easily made (map-like skull, exophthalmos and diabetes insipidus) but many of our cases have lacked the latter two features and some have had long bone lesions which gave the presenting symptoms A skeletal survey may in such cases disclose other areas which had not been suspected Metastatic bone disease may rarely present a similar appearance (neuroblastoma)

EOSINOPHILIC GRANULOMA

This disorder believed to be a phase of the two preceding diseases has its greatest incidence in older children adolescents and young adults The onset of the process is insidious symptoms may be insignificant and may be present for a long period prior to first observation

Lesions appear on X ray films as wholly radiolucent areas irregular in shape but often roughly spherical quite sharply circumscribed and even punched-out. Obviously of medullary origin, they tend to destroy the cortex from within but seldom distort the shape of the bone Perforation of the cortex may occur and then slight reactive new bone formation may be seen but this is not a prominent feature In older patients metastatic carcinoma or plasma cell myeloma may be suggested in younger patients, Ewing's sarcoma medullary fibrosarcoma or central chondrosarcoma may resemble this condition

LIPID STORAGE DISEASES

GAUCHER'S DISEASE

This rare affection characterized by chronic anemia enlarged spleen and large lipid-containing cells (kerasin) throughout the hemopoietic system has an insidious onset, periods of remission and a protracted course Since in addition to the spleen

the skeletal system is the most constant focus of the disease it follows that there are important bone changes There is absorption decalcification sclerosis and resulting therefrom deformities in outline particularly of the vertebrae and femur In the distal half of the latter there is often produced a peculiar appearance due to thinning of the cortex which resembles the outline of an Erlenmayer flask. These areas reveal replacement of the normal marrow by Gaucher's cells Vertebral involvement resembles tuberculosis rather than neoplastic disease although the intervertebral disks are not affected

NIEMANN PICK DISEASE

This rare disease shows a predilection for children of Jewish parentage It is congenital and familial and is usually noted in infancy It may be described as an essential lipid histiocytosis The lipid involved is the diaminophosphatid syringomyelin The skeletal changes in this condition are much less noteworthy than those in Gaucher's disease in fact slight osteoporosis of the cranial bones and the major long bones are all that is usually detected The prominence of the other aspects of the disease makes confusion with other bone diseases unlikely Therefore it is of only academic interest to those primarily concerned with roentgenographic diagnosis of skeletal affections

FIBROCYSTIC DISEASES

HYPERPARATHYROIDISM

This disease first described by Recklinghausen in 1891 and termed by him *osteitis fibrosa cystica* has been fully established as due to hypersecretion of the parathyroid glands Usually a single parathyroid becomes adenomatous

Clinical symptoms and signs of skeletal changes are often slight, with pain that is mild and intermittent Fracture of one of the bones may lead to the diagnosis Once the disease is suspected a study of the serum calcium phosphorus and phosphatase will generally confirm it Moreover there is a tendency to form calculi in the kidney pelvis a feature of this disease which is due to hypercalcemia. Cases are occasionally discovered when after a scout film of the kidney region discloses calculi blood chemical determinations are made

Roentgenographic examination of the skeleton reveals marked individual variation in the appearance extent localization, and multiplicity of the lesions In the earlier stages decalcification may produce a miliary mottled granular texture which is especially noted in the skull and flat bones In the tubular long bones the trabeculae

become indistinct while the cortex is thinned. Later cyst-like areas appear and some may suggest areas of fibrous dysplasia and others resemble tumors and contain giant cells which in the past have been mistaken for giant cell tumors

DISEASES DUE TO CIRCULATORY DISTURBANCES IN BONE

Aseptic Necrosis

The end result of an aseptic infarction of a portion of bone due to an interruption of a nutrient vessel is a hypercalcified area which presents a fairly typical roentgenographic appearance Local acute trauma or embolism by a small blood clot (bone infarct) may be the etiologic factor the most frequent cause however is embolism from nitrogen bubbles consequent to rapid lowering of atmospheric pressure Thus the condition is seen in divers sandhogs and caisson workers in general It seems also probable that jet pilots making rapid ascents to very high altitudes might be subject to this condition under circumstances affecting the pressure within the airplane cabin Other conditions in which an associated bone infarction has been described are sickle cell anemia and rheumatic fever

When the weight bearing bones are involved near their articular surfaces collapse of a portion of the affected area may induce deformity which in time may give rise to arthritic changes

The lesions are almost always located in major long bones and are more frequent in the lower than in the upper extremity Roentgenographic appearance is that of an irregularly increased density usually surrounded by a thin band of calcification while the shaft is not expanded and the cortex is not altered The lesions are usually diaphyseal and may extend into the epiphysis with secondary joint changes as mentioned above The condition is usually seen in more than one bone which serves to distinguish it from chronic sclerosing osteitis which it somewhat resembles It is not associated with as much pain as is seen in low-grade sclerosing osteogenic sarcoma Calcifying enchondroma is usually expansile and does not as a rule produce joint alterations When an area that is suggestive of aseptic necrosis is found other major long bones should be examined roentgenographically

Calcinosis (Tumoral Form of Inclan)

Large calcified masses giving rise to bulky tumors which appear to have arisen from bursae and spread to involve muscles have been described by Inclan who reported 3 cases. Radiographic examination revealed a massive extremely dense ovoid or spheroid tumor which, on a single film could not be distinguished from a sclerosing

osteogenic sarcoma or a calcified osteoma Stereoscopic examination should establish the fact that the bone is not involved the process being confined to soft tissues.

DISEASES DUE TO TRAUMA

Ossifying Hematoma (Myositis Ossificans Traumatica)

The condition known as ossifying hematoma or traumatic myositis ossificans is apt to be confused in its early phases with an osteogenic sarcoma Not only is the roentgenographic picture similar but even the microscopic appearance may be so similar as to make a correct interpretation difficult. Moreover a palpable fixed firm or hard swelling is evident on clinical examination which is suggestive of a true neoplasm.

Roentgenographic examination should always include stereoscopic views because they will reveal an intact cortex and establish the fact that the bone is not destroyed or invaded It is during the period of from one to four weeks after the injury that the roentgenologist will find it most difficult to distinguish between myositis ossificans and osteogenic sarcoma Thereafter myositis ossificans assumes a more and more orderly appearance and progressively looks less and less like sarcoma When doubt still exists after all the evidence is at hand one is fully justified in pursuing a course of close observation with frequent re-checking of the roentgenographic findings

Finally it should be mentioned that there have been rare instances of late development of a true osteogenic sarcoma on the basis of myositis ossificans

Fatigue Fracture (March Fracture)

In war time the frequency of march fracture is such that roentgenologists are alert to its possible presence as an explanation of a zone of increased density about an almost imperceptible line or crack across a long bone and especially a metatarsal. In the early proliferative stage of such a fracture in the uncommon sites such as proximal tibia femoral neck, or pubic ramus one may readily suspect that the condition is a bone sarcoma

Periosteal Tear

The action of a severe trauma sustained over a circumscribed area of bone without producing a fracture may result in a tearing or splitting of the periosteum and thereafter a productive new bone formation sometimes results which leads the observer to suspect on roentgenographic examination that an early bone sarcoma is present. The confusion arises only in a brief period following the injury for the

appearance rapidly becomes more typical of orderly bone repair and less like bone formation

DISEASES OF UNCERTAIN ETIOLOGY

Osteitis Deformans (Paget's Disease of Bone)

The complication of osteogenic sarcoma arising on an area of osteitis defor has already been discussed (see Chapter 1) However osteitis deformans unc cated by such a transformation is a skeletal disease which the roentgenologis occasionally be required to distinguish from bone tumors

In the early phase of this disease which is characterized by lytic lesions r than productive ones with irregular bone formation the roentgenographic ap ance may suggest fibrous dysplasia or a typical metastatic cancer or even a di destruction from hyperparathyroidism Blood chemistry and skeletal survey clarify the diagnosis

When the disease affects the pelvis and lumbar spine in males there may close similarity to metastatic prostatic cancer and the acid phosphatase level in serum will in such cases be of great assistance. Changes in shape size and stru of the bone are characteristic of osteitis deformans. The peculiar associatio osteoporosis and osteosclerosis which completely alters the normal trabecular tern is so distinct in many cases as to suggest the diagnosis at first glance.

Leontiasis Ossea

This term first applied by Virchow in 1865 is a descriptive one rather th pathologic entity Hence there are a number of types which may be due to diff etiologic factors Among these are fibrous dysplasia localized osteitis deforr *chronic or creeping periostitis diffuse osteitis cystic lesions of hyperparathyroi* adamantinoma of superior maxilla and finally true neoplasms of slow growth

The bone changes are as would be expected widely divergent according to underlying pathology They are osteoblastic osteolytic or a combination of both such descriptive terms as cotton like rarefaction fluffy moth-eaten woolen cloth have been applied

Melorheostosis

A rare bone affection first described in 1922 by Léri and Joanny present irregular cortical and periosteal swelling *involving the shaft of a long bone or* n

frequently several long bones of a single extremity. Usually a rather extensive portion of the shaft is affected and on one aspect rather than circumferentially so that the appearance on an X-ray film has been likened to honey flowing on a stick or like candle wax dripping along one side of a candle.

When such a lesion is found on roentgenograms it is important to make a complete study of films of the entire extremity as an isolated area may be mistaken for sclerosing osteitis, osteoid osteoma, lues or even a long-healed pyogenic periostitis. The etiology of the condition is obscure but some observers have considered that it may be related to a metameric embryological disturbance. No case of malignant transformation has ever been described.

Phantom Bone (Spontaneous Absorption of Bone)

This exceedingly rare condition affecting bone is characterized by slow progressive absorption of bone. Up to the present time we know of only half a dozen case reports in medical literature and we have personally observed a single case (that reported by Branch) but have seen the films and sections of two others.[1] Most of the cases have involved the bones of the shoulder girdle and the process is not confined to a single bone but extends to adjacent bones. Thus one case commencing in the clavicle later affected the acromion process, neck and supraspinous portion of the scapula. Another clavicle case showed involvement also of the first rib. The essential bony lesions in a third case included the clavicle and later the scapula, upper humerus, upper three ribs, and sixth and seventh cervical vertebrae. The roentgenographic appearance is simply that of complete absence of bone in the area involved and this area becomes progressively more extensive as time goes on; no form of treatment seems to arrest or even retard its progress.

Infantile Cortical Hyperostosis

This peculiar lesion was first described by Caffey and Silverman in 1945 and one year later by Smyth. It is a disease of the early months of the first year of life which is characterized by tender soft-part swellings, striking bone changes and a febrile reaction. The etiology and pathogenesis are obscure. Fortunately the process is self limited and runs its course apparently without influence of therapy. Lesions are frequently multiple and are featured by a pronounced thickening of cortical bone of the shaft. The epiphyses, metaphyses, centers of ossification and cancellous bone areas are unaffected.

Our experience with four cases which were all suspected of being bone sarcoma

[1] *Neoplasms of Bone* (Paul B. Hoeber Inc., 1949, pp. 659-698.)

leads us to include this disease among those which require consideration in a differential diagnosis The microscopic appearance is not that of a malignant neoplasm

AGNOGENIC MYELOID METAPLASIA

This condition the etiology of which is as yet not understood is characterized by great chronicity anemia with splenomegaly and hepatomegaly but without lymph adenopathy Bone pain is one of the symptoms and is due apparently to encroachment by fibrous tissue and sclerosis The patient may have the disease for fifteen to thirty years often with no complaint. Symptoms of anemia usually first bring the patient to a doctor The roentgenographic picture in the early stages shows a loss of the normal trabeculation and thinning of the cortex with lessened density In the later stages the bone becomes thickened and osteosclerotic with increased density in both cortex and medulla. Both findings may be present at the same time.



FIG. 130 *Osteomyelitis of pyogenic origin* The oval area of marked radiolucence is associated with a wide fusiform zone of periosteal reactive bone formation on the lateral aspect of the cortex the latter is not actually destroyed. The organism obtained at operation was a staphylococcus. The patient was a 21 year-old woman

Medullary fibrosarcoma might require differential diagnosis.

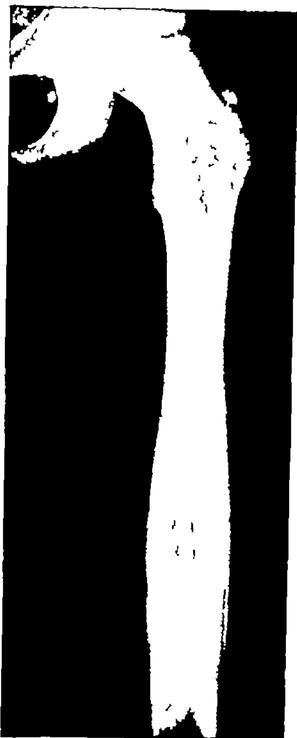


FIG. 131 *Osteomyelitis in 6-year-old boy* This view suggests very strongly the presence of Ewing's sarcoma rather than bone infection The diaphysial origin the wide extent of shaft involved the lamellated reactive cortical new bone and the central area of osteolysis made this case one in which a microscopic examination was required for a correct diagnosis. Five year follow up



Fig 132 *Osteomyelitis of radius* This film of the bones of the forearm of a 14 year old girl is rather typical of a chronic long standing osteomyelitis. While there is no obvious sequestrum the normal outline of the bone is threaded with an involucrum-like formation of new bone. The margins on the radial side are clearly shown and they present a sharply circumscribed border which is slightly scalloped at the center of the shaft. At the junction of the lower fourth with the upper three fourths are two separate radiolucent areas which probably represent abscess cavities. This case was seen in the Bone Tumor Clinic as a possible neoplasm but the diagnosis of *Staphylococcus aureus* osteomyelitis was confirmed at operation.



FIG 133 *Pyogenic osteomyelitis with pathologic fracture* The patient was an 11 year-old boy This case so closely simulated a primary bone sarcoma that most of those who saw him in the hospital made that diagnosis. Note especially the strands of reactive bone on the medial and lateral aspects of the proximal third of the femur the finely granular appearance of the shaft below the trochanter and the involvement of the head of the femur At operation tissue report was inflammatory (granulation tissue, no tumor cells were found)



FIG. 134 *Low-grade subacute osteomyelitis of the femur* This 50-year-old male with a three month history of constant aching pain in the thigh was seen by several doctors and finally referred to the Bone Tumor Clinic with a diagnosis of possible osteogenic sarcoma The films revealed a combination of bone destruction and bone production. The destructive area is slightly lobulated into three portions and occupies the medullary cavity On the lateral aspect the cortical line is unbroken and on X-ray examination appears to be quite uninvaded. On the medial aspect, however over an area slightly greater in extent than the obvious medullary involvement there is a marked alteration in the cortex. This is characterized by destruction of the normal cortical outline and thinning of it in places and a productive new bone formation which is fairly well circumscribed and lacks either the lamellar arrangement of Ewing's sarcoma or the striations at right angles to the shaft of the bone which are often seen in osteogenic sarcoma. In such a lesion microscopic or bacteriologic confirmation is also essential Both were obtained in this case



FIG 137 *Syphilitic osteitis* A wide extent of the fibular shaft is seen to be involved both lytic and productive changes are present. There is a pathologic fracture at about the middle portion of the bone The lesion is somewhat unusual because it is largely lytic with very little productive periostitis. It could easily be mistaken for a neoplasm. Note also the bulky soft tissue mass over the proximal end of the tibia which erodes the adjacent cortex. Syphilis of bone can resemble a wide variety of skeletal conditions including bone sarcoma and metastatic cancer

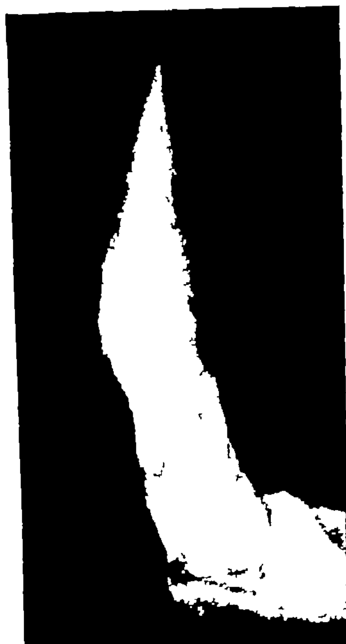


FIG. 138 *Sporotrichosis of bone caused by Sporotrichum schenkii* Localized expansion of bone which is denser and more sclerotic than normal The peripheral margin of the projecting process has a rather sharply circumscribed edge Presumably from this single exposure a diagnosis of sclerosing osteogenic sarcoma might be made Note also the joint involvement which, however would help to exclude malignant tumor This is one of the extremely rare affections of the skeletal system



FIG 139 *Hydatid disease of the ilium* Note the marked expansion and bone destruction together with calcific deposits which simulate new bone formation This case was regarded as chondrosarcoma until biopsy disclosed its true nature In fact the roentgenographic appearance is strikingly similar Osseous manifestations of hydatid disease are rare in this country only about a dozen cases have been reported. In Argentina, Australia parts of China, and the Mediterranean area the condition is not infrequently found.



FIG 140 *Letterer-Siwe disease* Lesions are seen in the humerus and rib The former is characterized by a diffuse lytic area without expansion of the cortex the latter expands the cortex and appears as an area of bone destruction with multiple small loculi. This uniformly fatal disease affecting infants under 2 years of age is usually manifested by the symptoms and signs and not primarily by the roentgenograms.



FIG 141 *Letterer Siwe disease—same case as Fig 140* Showing a well-circumscribed loss of bone in the supraorbital and temporal area on the right, and a small almost spherical area of similar nature on the left. Similar skull defects in older children are seen in cases of Hand-Schüller-Christian's syndrome



Fig 142 *Hand Schüller Christian disease* The striking feature seen in this view is the varying degree of collapse of some of the dorsal and lumbar vertebral bodies, some of which are almost wafer thin There are lytic changes in some of the bodies which have not yet collapsed. This patient recovered and is well eighteen years later Recent films reveal a vertebral column which shows no evidence of previous collapse



FIG 143 *Hand Schüller-Christian disease* Note multiple sharply circumscribed areas of complete loss of bone which are quite typical of skull lesions of this disease to which the term "map-like skull" has been applied. The other features of the triad are diabetes insipidus and exophthalmos, but many cases are seen in which the latter findings are absent.



FIG 144 *Hand-Schuller-Christian disease (eosinophilic granuloma)* Same case as Fig 143 The disease has affected both femora and the lesions have a somewhat multilocular tendency There is practically no reactive bone in the lesion in the shaft of the left femur but on the medial aspect of the right femur productive bone is seen This patient was a male child of 3 whose serum calcium phosphatase phosphorus and protein levels were normal This case was one of the fatal forms of Hand Schüller Christian disease The patient succumbed about five months after he was first seen.

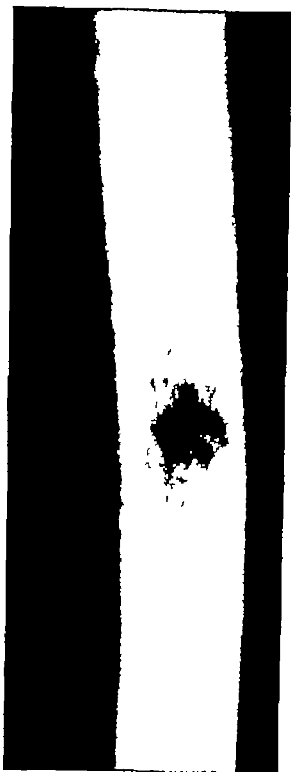


FIG. 145 *Eosinophilic granuloma.* This humeral lesion appeared in a 17 year-old boy It is unicameral medullary osteolytic and fairly sharply outlined. Such lesions have been mistaken for various types of medullary malignant disease such as central medullary sarcoma Ewing's sarcoma, or even metastatic carcinoma If accessible to aspiration biopsy the diagnosis may often be confirmed by the pathologist. These lesions are radiosensitive the use of curettage and bone chips is also recommended, especially when the condition is not recognized until operation has been undertaken

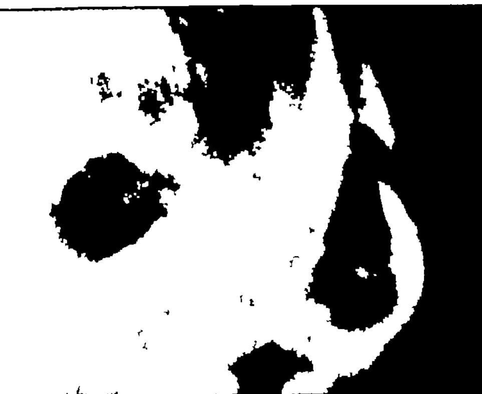


FIG. 136 *Eosinophilic granuloma in a young man* The purely destructive lesion in the squamous portion of the temporal bone presents abrupt though irregular margins with no reactive peripheral zone of increased density

Treatment was surgical and the case has been followed for thirteen years with no further symptoms

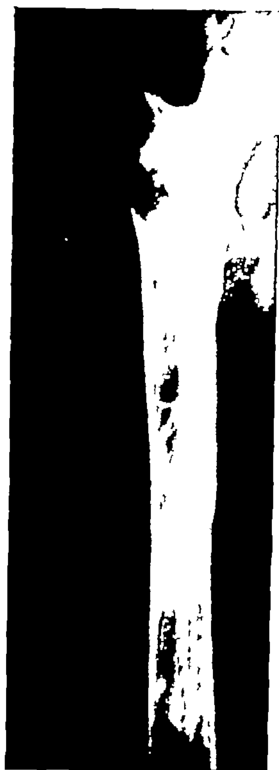


FIG 147 *Gaucher's disease* Extensive involvement of the femur in a 33 year-old man characterized chiefly by marked osteolysis which is particularly noticeable in the lower third by thinning of the cortex, and by a slight tendency to septate arrangement. At the junction of the middle and lower thirds, a narrow zone of increased density is seen There is some deformity of the head of the femur with sclerosis This lesion requires differentiation from fibrous dysplasia and in some instances may resemble a low-grade medullary fibrosarcoma or even metastatic carcinoma.



FIG. 148 *Gaucher's disease* This view depicts the appearance of a long standing Gaucher's disease affecting the shaft and metaphysis of the femur The expansion to which the term "Erlenmayer flask" has been given is not conspicuous in this instance but the thinning of the spongiosa and the endosteal secondary calcification point to the process being of long standing Other skeletal lesions of the disease were present. This patient was a man of 57 years.



FIG 149. *Gaucher's disease* Characteristic Erlenmayer flask expansion of distal diaphyseal and metaphyseal portions of the bone are seen The destructive phase is accompanied by a mottled patchy area of reparative bone and calcification In order to arrive at a correct diagnosis it is helpful to ascertain the presence of splenomegaly Biopsy of a bone lesion will make identification easy as the microscopic picture is quite characteristic.



FIG. 150 *Hyperparathyroidism (osteitis fibrosa cystica generalisata).* Multilocular cystic process in shaft of an adult long bone This film was made after removal of a parathyroid adenoma and recalcification of distal end of radius has occurred but the cystic area proximal thereto has persisted. Subsequent operation with bone transplant was followed by complete recalcification



FIG. 151 *Hyperparathyroidism.* Osteolytic area in the mid shaft of the femur in a patient from whom a parathyroid adenoma was subsequently removed. The margins of the lesion are less clearly defined than is usually the case with fibrous dysplasia. The appearance can be simulated closely by an area of plasma cell myeloma or metastatic cancer. Renal calculi were also demonstrated. The serum calcium, phosphorus, and phosphatase values were characteristically altered.

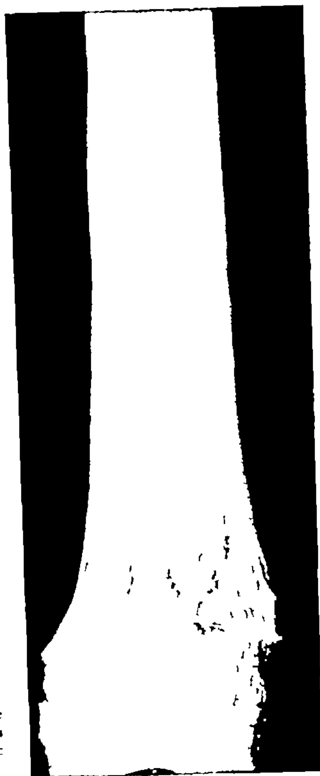


FIG 152 *Aseptic necrosis of bone (Caisson disease).* Note that the changes lie entirely within the normal confines of the bone the outline of which is not altered and that these changes consist in a mottled, irregular calcific deposit which has replaced the normal trabecular pattern Distally the process is more sharply outlined and scalloped. This patient gave a history of exposure to atmospheric changes while working as a sandhog Other long bones were similarly involved. No microscopic confirmation was obtained.

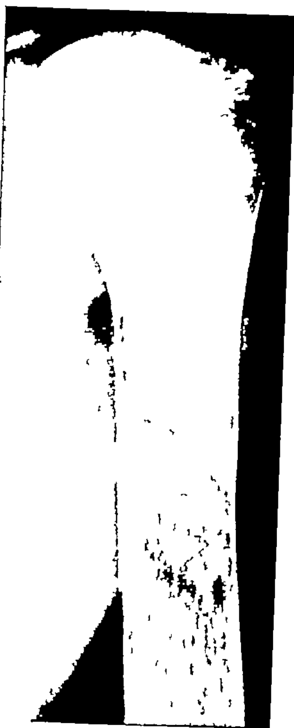


FIG 153 *Renal rickets.* The entire visible portion of the humerus shows profound osteoporosis which seems to have progressed as an endosteal and medullary absorption of bone trabeculae and yet has preserved intact the outermost layers of the cortex. The process is unusually diffuse and homogeneous. Sections of other bones at autopsy revealed microscopic evidence of diffuse bone involvement not detectable on roentgenograms. The disease most closely simulating it roentgenographically is hyperparathyroidism



FIG 154 *Infantile scurvy* Note the tremendous extent of the new bone formation which involves the femur from the distal epiphyseal line almost to the lesser trochanter The striking feature here is that this new bone is laid down around the intact cortex and that it is rather sharply circumscribed peripherally The lesions with which it might be confused are infantile cortical hyperostosis or syphilis. Florid cases of infantile scurvy are now rarely seen in the United States.



FIG 155 *Neuropathic bone changes* Patient had spina bifida with meningomyelocele and cord bladder Note the destructive process in the right femoral neck and the hyperplastic bone formation in the lower half of the left femur A rubber suprapubic cystostomy tube is seen. Cases such as this appear to be rather frequent in patients suffering from paraplegia, and reports from veterans hospitals have emphasized their occurrence in paraplegic soldiers.

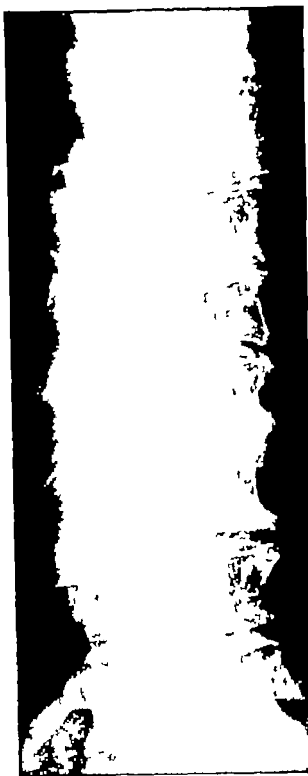


FIG 156 *Postmenopausal osteoporosis in a 61 year-old woman* The entire lumbar spine shows a diminution in bone density which is diffuse and homogeneous The vertical diameter of some of the vertebrae has been reduced. Occasionally one or more bodies may be conspicuously collapsed and the question of myeloma or metastatic cancer then may arise



FIG 157 *Postmenopausal osteoporosis with compression fracture and deformity of the twelfth dorsal vertebra* The features noted in Fig 156 are seen here. The diffuse osteoporotic appearance is somewhat similar to the condition seen in extremities which is called Sudeck's bone atrophy or disuse atrophy of bone following prolonged immobilization. Postmenopausal osteoporosis is rarely seen in the skull or the extremities but is generally confined to the vertebral column.



FIG 158 *Myositis ossificans (ossifying hematoma)* This myositic condition has caused confusion in the microscopic differentiation from osteogenic sarcoma. Its roentgenographic appearance is usually more reliable than the microscopic. The most important feature is the absence of any involvement or destruction of the cortex, the cortical line beneath the tumor being completely unbroken. In some cases it requires a stereoscopic study to confirm the presence of this intact cortical line The productive bone fades by insensible gradations at either end of the process and presents a relatively smooth outline on its convex surface. From the first appearance of new bone formation the difficulties in roentgenographic interpretation steadily decrease with the passage of time, the tendency being for the appearance to resemble less and less an osteogenic sarcoma as the process develops a more adult type of bone In cases of doubt and where there is no involvement of the cortex whatsoever a delay of two to three weeks may be justified which should be followed by a second roentgenographic examination This will often confirm the presence of an ossifying hematoma.



FIG 159. *Myositis ossificans (ossifying hematoma)* In this instance, the formation of bone is not attached to the adjacent humeral shaft. Where such attachment is present the diagnosis in the *early* phase of the lesion's development is sometimes difficult Of great assistance is the knowledge that the condition follows rather shortly after a definite muscle trauma This case was not confirmed microscopically



FIG. 160 *Osteitis deformans (Paget's disease of bone).* In this view the sclerosing or productive phase predominates although there are multiple small lytic areas. In cases such as this the serum alkaline phosphatase is usually markedly elevated but the calcium and phosphorus are normal. Metastatic prostatic cancer may give a somewhat similar appearance. The acid phosphatase level is never elevated in Paget's disease but usually is in metastatic prostatic carcinoma.



Fig 161 *Osteitis deformans (Paget's disease of bone)* Same case as Fig 160 Here are shown both productive and destructive phases in close proximity Marked bowing of the tibia is taking place The destructive phase precedes the productive or *healing* phase and leads to stresses and strains which in turn stimulate osteoblasts to lay down more matrix with resultant rise in the alkaline phosphatase level In the long bones and vertebrae bone repair occurs practically simultaneously with bone destruction. The calvarium is frequently involved and enormous thickening may result in progressive increase in the size of the head.



FIG. 162 *Osteitis deformans with metastatic cancer* The visible portion of the skeleton reveals classical features of Paget's disease but in the head and neck of the femur there is a superimposed malignant tumor While one would readily assume that it is osteogenic sarcoma on Paget's disease, it was microscopically proved to be metastatic renal carcinoma which had not been suspected. We have seen other similar cases involving primary lung and colon tumors so that while sarcoma on Paget's disease is still the most logical explanation for a malignant lesion engrafted on a bone showing the characteristics of Paget's disease one must always realize that it may also be metastatic cancer



FIG 165 *Osteoporosis circumscripta* The anterior half of the calvarium presents almost complete loss of bone with a sharply demarcated margin. In the frontal area, irregular patches of bone are seen which presumably represent the beginnings of the productive phase of the underlying disease which is osteitis deformans (Paget s disease) In support of the theory that it is related to or a manifestation of early Paget s disease is the fact that more than two-thirds of the reported cases showed other skeletal manifestations of the latter disease.



FIG. 164 *Hyperostosis frontalis interna* Pathognomonic of this condition are the fact that hyperplastic bone is laid down within the vault and extending from the inner table without affecting the outer table in any way and that the margins are smooth and sharply circumscribed The etiology of the disease is unknown and its appearance is quite distinctive on X ray examination and should not cause any diagnostic difficulty

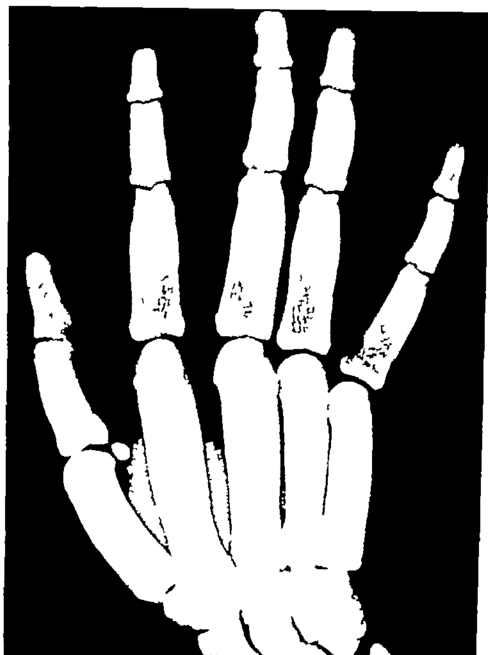


FIG 165 *Osteopetrosis (Albers-Schonberg disease marble bone)* There is marked increased radiopacity and the normal configuration of the bones is modified the process is homogeneous and diffuse. All the bones show this increased density which causes a complete or partial loss of the normal architecture of the bone. Familial traits are striking *Consanguinity of the parents* has been a frequent occurrence and was noted in about one half of the reported cases.



Fig. 166 *Osteopetrosis (Albers-Schönberg disease marble bone)* The same condition as shown in Fig 165 involving the bones of the forearm The spongiosa cortex, and medullary cavity are obliterated. This patient was one of eight children four of whom were known to have osteopetrosis.



FIG 167 *Osteopetrosis (Albers Schönberg disease marble bone)* Same case as Fig 166 Even the skull is involved with almost complete loss of detail of the bones of the calvarium maxilla, and mandible One case has been reported where osteopetrosis was complicated by a typical sclerosing osteogenic sarcoma of the femur in a 20-year-old Negro man Osteopetrosis is not associated with abnormal levels of serum alkaline phosphatase

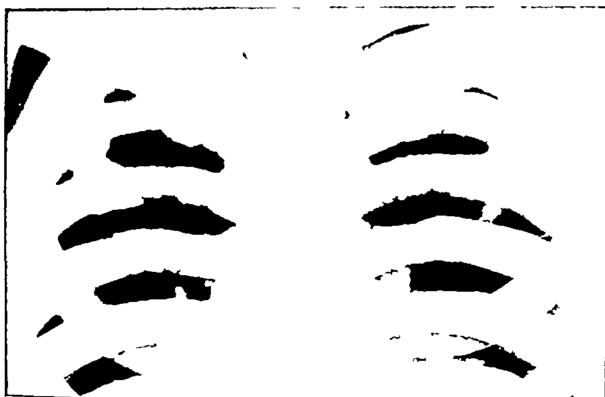


FIG. 168 *Osteopetrosis (Albers-Schönberg disease marble bone).* A similar appearance is shown in this film of the thoracic cage Four siblings were similarly affected and consanguinity of parents may have been a factor Superficially this disease may resemble chronic fluoride poisoning roentgenographically In fluoride poisoning the architecture of the bone is usually well preserved and the epiphyses are demonstrable long after they normally should disappear

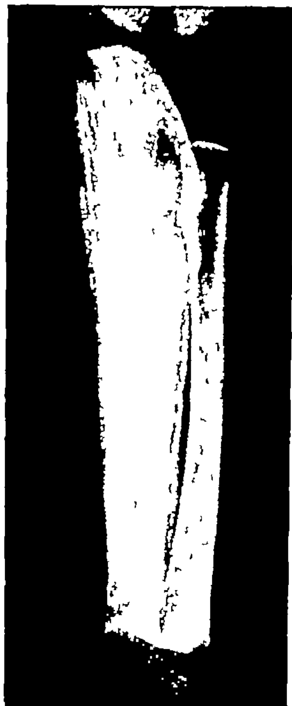


FIG 169 *Infantile cortical hyperostosis in a female infant aged 3 months.* The ulna is involved almost in its entirety New bone production has greatly widened the shaft but in an orderly fashion The scapula and mandible are more often affected than the tubular long bones. The condition usually appears in the early months of the first year of life Its etiology is unknown and its pathogenesis is obscure It is a self limited process and runs its course apparently uninfluenced by therapy We have seen 4 cases where a diagnosis of bone sarcoma had been made and amputation had been seriously considered



FIG 170 *Agnogenic myeloid metaplasia* A dense sclerotic process involves both innominate bones and the lumbar vertebrae. In some areas there is thinning of the cortex. The patient also suffered from anemia and splenomegaly with hepatomegaly



Fig 171 *Agnogenic myeloid metaplasia (same case as Fig 170)* The skull and cervical vertebrae are seen to be similarly involved as were other bones. The roentgenogram also shows thinning of the cortex and patchy sclerosis (see p 161)

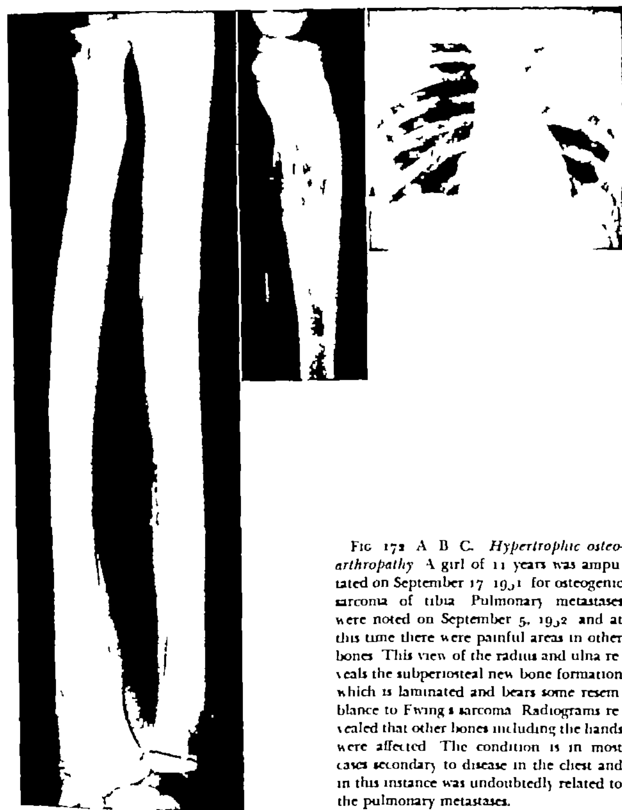


FIG 172 A B C. *Hypertrophic osteo-arthropathy* A girl of 11 years was amputated on September 17 1931 for osteogenic sarcoma of tibia Pulmonary metastases were noted on September 5, 1932 and at this time there were painful areas in other bones This view of the radius and ulna reveals the subperiosteal new bone formation which is laminated and bears some resemblance to Ewing's sarcoma Radiograms revealed that other bones including the hands were affected The condition is in most cases secondary to disease in the chest and in this instance was undoubtedly related to the pulmonary metastases.

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